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BULLETIN

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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION.

INQUIRY INTO QUESTIONS OF GENERAL INTEREST.

(Decision taken by the Permanent Commission at its Meeting held on July 9th, 1938.)

QUESTION I.

Methods used to speed up passenger trains and the resulting expenditure. In particular, operating by means of railcars and the financial results obtained by this method.

REPORT

(Germany, Bulgaria, Denmark, Hungary, Norway, Sweden and Switzerland),

by Ministerialrat ROHDE
Ministerialrat STROEBE (railcar questions)
Reichsbahndirektor FESSER (locomotive questions)
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I. — General.

The desire for ever faster communications which is a characteristic of our times, and the ever keener competition of the road motor vehicle have obliged Railway Managements to undertake a general speeding up of their passenger trains. This question is closely linked up with that of higher train frequency. In fact, the time taken for a journey depends not only on the average speed of the method of transport, but also to a great extent on the frequency of the service. The importance of this latter factor is the greater the shorter the journey, while as the distance increases, it is the speed which plays the most decisive part in the total time taken for the journey. This means that competition from the private motor car, which the owner can use at any time, is particularly severe as regards short-distance and suburban traffic of large cities, regional traffic of industrial districts, and traffic on secondary-line systems in thinly inhabited districts, where there is no interest in having trains running at close intervals.

On the other hand, in the case of air competition, most of the Administrations who replied to this question reported that the railways have not yet felt its effects. Only the Swiss Federal Rys. stated that it was partly due to such competition that they had to speed up their passenger trains. It might also be mentioned that the fast railcar services introduced by the Deutsche Reichsbahn in recent years between many of the important German towns and Berlin can, and are intended to, meet air competition. These fast railcar services make it possible to travel from Berlin to a town as far as 700 km. (435 miles) away and get back the same day after spending enough time there to get through one's business; formerly this was only possible by aeroplane.

In order to speed up the passenger trains to the desired extent, the railways could take the following steps :

1. Eliminate or shorten stops;
2. Reduce the weight of the trains;
3. Obtain better utilisation of the existing tractive power;
4. Make constructional improvements in the steam and electric locomotives;
5. Replace steam traction by electric traction;
6. Improve the lines;
7. Improve the signals and brakes;
8. Use railcars.

By means of such steps, in the last few years most Railway Managements have succeeded in considerably speeding up both their express trains and local trains. The most striking speeding up, however, is that of the express trains, such services being completed by the introduction of new fast railcar services between the large towns.

Table 1 lists the trains reaching speeds of 96 km./h. (60 m.p.h.) and over, in the countries covered by this report.

Table 2 shows the ratio of such trains to all the passenger trains of the various Companies.

TABLE 1.

Express trains running at 96 km./h. (60 m.p.h.) and over between two stops.

1	2	3	4	5		6	7	
Serial number	Train number.	Non-stop runs. From	Non-stop runs. To	Distance km.	Distance *miles.*	Time spent, July 1938. Mins.	Hourly speed, July 1938. km.	Hourly speed, July 1938. *miles.*
		I. Deutsche Reichsbahn.						
		A. Steam locomotives.						
1	FD 24	Berlin Lehrt.Bf.	Hamburg . . .	286.8	*178.2*	149	115.5	*71.8*
2	FD 23	Hamburg . . .	Berlin Lehrt.Bf.	286.8	*178.2*	151	114.0	*70.8*
3	D 53	Dresden-N. . .	Berlin Anh. Bf.	176.0	*109.4*	95	111.2	*69.1*
4	D 58	Berlin Anh. Bf.	Dresden-N. . .	176.0	*109.4*	97	108.9	*67.7*
5	D 54	Berlin Anh. Bf.	Dresden-N. . .	176.0	*109.4*	99	106.7	*66.3*
6	D 57	Dresden-N. . .	Berlin Anh. Bf.	176.0	*109.4*	99	106.7	*66.3*
7	D 91	Magdeburg . .	Brandenburg .	80.6	*50.1*	46	105.1	*65.3*
8	D 177	Magdeburg . .	Potsdam . . .	115.8	*72.0*	67	103.7	*64.4*
9	D 27	Magdeburg . .	Brandenburg .	80.6	*50.1*	47	102.9	*63.9*
10	FD 5	Leipzig . . .	Berlin Anh. Bf.	164.3	*102.1*	97	101.6	*63.1*
11	FD 102	Baden-Oos . .	Freiburg (Br.).	103.0	*64.0*	61	101.3	*63.0*
		Mannheim . .	Karlsruhe . .	60.7	*50.1*	36	101.2	*62.9*
12	FD 101	Freiburg (Br.).	Baden-Oos . .	103.0	*64.0*	61	101.3	*63.0*
13	FD 80	Berlin Anh. Bf.	Halle (Saale) .	161.7	*100.5*	96	101.1	*62.8*
14	D 178	Potsdam . . .	Magdeburg . .	115.8	*72.0*	69	100.7	*62.6*
15	FD 6	Berlin Anh. Bf.	Leipzig . . .	164.3	*102.1*	98	100.6	*62.5*
16	FD 7	Leipzig . . .	Berlin Anh. Bf.	164.3	*102.1*	98	100.6	*62.5*
17	D 118	Breslau . . .	Liegnitz . . .	65.1	*40.5*	39	100.2	*62.3*
18	D 342	Breslau . . .	Liegnitz . . .	65.1	*40.5*	39	100.2	*62.3*
19	D 1	Lehrte. . . .	Gardelegen . .	101.8	*63.3*	61	100.0	*62.1*
20	FD 22	Hanover . . .	Bielefeld. . .	109.5	*68.1*	66	99.5	*61.8*
		Berlin Zoo . .	Hanover . . .	254.1	*157.9*	156	97.7	*60.7*
21	FD 112	Hanover . . .	Osnabrück . .	132.5	*82.3*	80	99.4	*61.7*
		Berlin Zoo . .	Hanover . . .	254.1	*157.9*	154	99.0	*61.5*
22	FD 79	Halle (S.) . .	Berlin Anh. Bf.	161.7	*100.5*	98	99.0	*61.5*
23	FD 21	Hanover . . .	Berlin Zoo . .	254.1	*157.9*	154	99.0	*61.5*
24	FD 8	Berlin Anh. Bf.	Leipzig . . .	164.3	*102.1*	100	98.6	*61.3*
25	FD 17	Leipzig . . .	Berlin Anh. Bf.	164.3	*102.1*	100	98.6	*61.3*
26	FD 111	Hanover . . .	Berlin Zoo . .	254.1	*157.9*	155	98.4	*61.1*
		Osnabrück . .	Hanover . . .	132.5	*82.3*	81	98.1	*60.9*
27	FD 101	Karlsruhe . .	Mannheim . .	60.7	*37.7*	37	98.4	*61.1*
28	FD 25	Hamm (W.). .	Hanover . . .	176.5	*109.7*	108	98.1	*60.9*
		Hanover . . .	Berlin Zoo . .	254.1	*157.9*	159	95.9	*59.6*

TABLE 1 *(Continued)*.

Express trains running at 96 km./h. (60 m.p.h.) and over between two stops.

1	2	3	4	5		6	7	
Serial number.	Train number.	Non-stop runs. From	Non-stop runs. To	Distance km.	Distance *miles.*	Time spent, July 1938. Mins.	Hourly speed, July 1938. km.	Hourly speed, July 1938. *miles.*
29	FD 102	Emmerich . .	Duisburg . . .	68.5	*42.6*	42	97.8	*60.8*
30	FD 18	Berlin Anh. Bf.	Leipzig . . .	164.3	*102.1*	101	97.6	*60.6*
31	L 12	Hanover . . .	Hamm (W.). .	176.5	*109.7*	109	97.2	*60.4*
32	FD 26	Hanover . . .	Hamm (W.). .	176.5	*109.7*	109	97.2	*60.4*
		Berlin Zoo . .	Hanover . . .	254.1	*157.9*	166	91.8	*57.0*
33	L 11	Hamm (W.). .	Hanover . . .	176.5	*109.7*	110	96.3	*59.8*
			B. Electric locomotives.					
34	D 192	Breslau . . .	Königszelt . .	48.4	*30.1*	27	107.6	*66.9*
35	D 1010	Halle (Saale) .	Köthen . . .	35.8	*22.2*	20	107.4	*66.7*
36	FD 79	Augsburg. . .	Nuremberg . .	137.2	*85.3*	80	102.9	*63.9*
37	D 344	Halle (Saale) .	Köthen . . .	35.8	*22.2*	21	102.3	*63.6*
		Köthen . . .	Schönebeck . .	35.3	*21.9*	21	100.9	*62.7*
38	D 183	Magdeburg . .	Köthen . . .	50.2	*31.1*	30	100.4	*62.4*
39	D 1183	Magdeburg . .	Köthen . . .	50.2	*31.1*	30	100.4	*62.4*
40	D 159	Magdeburg . .	Köthen . . .	50.2	*31.1*	30	100.4	*62.4*
41	D 191	Königszelt . .	Breslau . . .	48.4	*30.1*	29	100.1	*62.2*
42	FD 79	Munich . . .	Augsburg. . .	61.9	*38.5*	38	97.7	*60.7*
		Total, steam and electric locomotives.		6 766.0	*4 204.7*			
			C. Express railcars.					
43	FDt 16	Hanover . . .	Hamm (W.). .	176.4	*109.6*	80	132.3	*82.2*
		Berlin Zoo . .	Hanover . . .	254.1	*157.9*	125	122.0	*75.8*
		Hamm (W.). .	Dortmund . .	31.3	*19.4*	17	110.5	*68.7*
		Duisburg. . .	Düsseldorf . .	23.6	*14.7*	14	101.1	*62.8*
44	FDt 15	Hamm (W.). .	Hanover . . .	176.4	*109.6*	81	130.7	*81.2*
		Hanover . . .	Berlin Zoo . .	254.1	*157.9*	129	118.2	*73.4*
		Dortmund . .	Hamm (W.). .	31.3	*19.4*	17	110.5	*68.7*
45	FDt 51	Hanover . . .	Berlin Zoo . .	254.1	*157.9*	119	128.1	*79.6*
		Bremen . . .	Hanover . . .	122.3	*76.0*	63	116.5	*72.4*
46	FDt 572	Berlin Anh. Bf.	Leipzig . . .	164.3	*102.1*	77	128.0	*79.5*
		Erfurt. . . .	Frankfort (M.)	268.6	*167.0*	146	110.4	*68.6*
		Mannheim . .	Karlsruhe . .	60.7	*37.7*	33	110.4	*68.6*
		Weissenfels . .	Weimar . . .	55.3	*34.4*	32	103.7	*64.4*
47	FDt 551	Leipzig . . .	Berlin Anh. Bf.	164.3	*102.1*	78	126.4	*78.5*
		Munich . . .	Nuremberg . .	198.6	*123.4*	108	110.3	*68.5*
48	FDt 571	Leipzig . . .	Berlin Anh. Bf.	164.3	*102.1*	80	123.2	*76.6*
		Karlsruhe . .	Mannheim . .	60.7	*37.7*	33	110.4	*68.6*
		Frankfort (M.)	Erfurt. . . .	268.6	*167.0*	148	108.9	*67.7*

TABLE 1 *(Continued)*.

Express trains running at 96 km./h. (60 m.p.h.) and over between two stops.

1	2	3	4	5		6	7	
Serial number	Train number.	Non-stop runs.				Time spent, July 1938. Mins.	Hourly speed, July 1938.	
		From	To	Distance				
				km.	*miles.*		km.	*miles.*
49	FDt 1	Hamburg . . .	Berlin Lehrt.Bf.	286.8	*178.2*	140	122.9	*76.4*
50	FDt 45	Berlin Schl. . .	Breslau . . .	329.5	*204.7*	161	122.8	*76.3*
		Oppeln. . . .	Heydebreck . .	41.5	*25.8*	21	118.6	*73.7*
		Breslau . . .	Oppeln. . . .	81.7	*50.8*	43	114.0	*70.8*
		Heydebreck . .	Gleiwitz . . .	37.1	*23.1*	20	111.3	*69.2*
51	FDt 46	Oppeln. . . .	Breslau . . .	81.7	*50.8*	40	122.6	*76.2*
		Heydebreck . .	Oppeln. . . .	41.5	*25.8*	21	118.6	*73.7*
		Gleiwitz . . .	Heydebreck . .	37.1	*23.1*	19	117.2	*72.8*
		Breslau . . .	Berlin Schl. . .	329.5	*204.7*	176	112.3	*69.8*
52	FDt 52	Berlin Zoo . .	Hanover . . .	254.1	*157.9*	125	122.0	*75.8*
		Hanover . . .	Bremen . . .	122.3	*76.0*	68	107.9	*67.0*
53	FDt 37	Osnabrück . .	Bremen . . .	122.1	*75.9*	61	120.1	*74.6*
		Bremen . . .	Hamburg . . .	115.5	*71.8*	59	117.5	*73.0*
		Münster . . .	Osnabrück . .	50.1	*31.1*	27	111.3	*69.2*
		Hamm (W.). .	Münster . . .	35.3	*21.9*	21	100.9	*62.7*
54	FDt 10	Berlin Lehrt.Bf.	Hamburg . . .	286.8	*178.2*	144	119.5	*74.3*
55	FDt 38	Hamburg . . .	Bremen . . .	115.5	*71.8*	58	119.5	*74.3*
		Bremen . . .	Osnabrück . .	115.5	*71.8*	63	116.3	*72.3*
		Osnabrück . .	Münster . . .	50.1	*31.1*	26	115.6	*71.8*
		Hamm (W.). .	Dortmund . .	31.3	*19.4*	17	110.5	*68.7*
		Düsseldorf . .	Cologne . . .	40.1	*24.9*	24	100.2	*62.3*
56	FDt 11	Hamburg . . .	Berlin Lehrt.Bf.	286.8	*178.2*	148	116.3	*72.3*
57	FDt 552	Berlin Anh. Bf.	Leipzig . . .	164.3	*102.1*	86	114.6	*71.2*
		Nuremberg . .	Munich . . .	198.6	*123.4*	113	105.5	*65.6*
58	FDt 2	Berlin Lehrt.Bf.	Hamburg . . .	286.8	*178.2*	153	112.5	*69.9*
59	FDt 28	Berlin Lehrt.Bf.	Hamburg . . .	286.8	*178.2*	160	107.6	*66.9*
60	Dt 722	Augsburg. . .	Ulm	86.0	*53.4*	49	105.3	*65.4*
61	Dt 723	Ulm	Augsburg. . .	86.0	*53.4*	49	105.3	*65.4*
62	Dt 724	Augsburg. . .	Ulm	86.0	*53.4*	49	105.3	*65.4*
63	FDt 27	Hamburg . . .	Berlin Lehrt.Bf.	286.8	*178.2*	164	104.9	*65.2*
64	Dt 722	Munich . . .	Augsburg. . .	61.9	*38.5*	36	103.2	*64.1*
65	Dt 721	Ulm	Augsburg. . .	86.0	*53.4*	52	99.2	*61.6*
66	FDt 571	Weimar . . .	Leipzig . . .	95.4	*59.3*	58	98.7	*61.3*
67	FDt 572	Leipzig . . .	Weissenfels . .	40.4	*25.1*	25	96.9	*60.2*
68	FDt 18	Hamm (W.). .	Hagen	48.3	*30.0*	30	96.6	*60.0*
69	FDt 17	Hagen	Hamm (W.). .	48.3	*30.0*	30	96.6	*60.0*
70	FDt 38	Münster . . .	Hamm (W.). .	35.3	*21.9*	22	96.3	*59.8*
71	FDt 15	Cologne . . .	Düsseldorf . .	40.1	*24.9*	25	96.2	*59.7*
72	FDt 16	Düsseldorf . .	Cologne . . .	40.1	*24.9*	25	96.2	*59.7*
		Total, express railcars.		7 598.0	*4 721.2*			

TABLE 1 *(Continued).*

Express trains running at 96 km./h. (60 m.p.h.) and over between two stops.

1	2	3	4	5		6	7	
Serial number.	Train number.	Non-stop runs. From	To	Distance km.	*miles.*	Time spent, July 1938. Mins.	Hourly speed, July 1938. km.	*miles.*
			II. **Danish State Railways.**					
73	11	Roskilde . . .	Korsör. . . .	79	*49.1*	49	97	*60.3*
74	17	Copenhagen . .	Slagelse . . .	93	*57.8*	...	101	*62.8*
75	15/33	»	Korsör. . . .	110	*68.4*	...	100/102	*62.1/63.4*
76	67	Roskilde . . .	Slagelse . . .	62	*38.5*	...	103	*64.0*
77	42/88	Korsör. . . .	Copenhagen . .	110	*68.4*	...	99	*61.5*
78	40/80/92	Slagelse . . .	Roskilde . . .	62	*38.5*	...	100	*62.1*
79	11	Odense. . . .	Middelfart . .	50	*31.0*	...	97	*60.3*
80	33/65	Nyborg . . .	Fredericia . .	90	*55.9*	...	97	*60.3*
81	40/92	Middelfart . .	Odense. . . .	50	*31.0*	...	97	*60.3*
82	42	Fredericia . .	Nyborg . . .	90	*55.9*	...	97	*60.3*
83	90	»	Odense. . . .	60	*37.3*	...	100	*62.1*
84	80	Skanderborg. .	Horsens . . .	29	*18.0*	...	97	*60.3*
			Total. . .	885 + 2 × (110 + 62) + 90 + 50 = 1 369 km. = *851 miles.*				
			III. **Swiss Federal Railways.**					
85	5	Geneva. . . .	Lausanne. . .	61	*37.9*	37	99	*61.5*
86	27	»	»	61	*37.9*	37	99	*61.5*
87	6	Lausanne. . .	Geneva. . . .	61	*37.9*	37	99	*61.5*
88	24	»	»	61	*37.9*	37	99	*61.5*
			Total. . .	244	*151.6*			

TABLE 2

1	2	3		4		5
Serial number.	Administration.	Average daily distance covered by all passenger trains together km.	*miles.*	by passenger trains running at 96 km./h. *(60 m. p. h.)* and over, between two stops km.	*miles.*	Col. 4 as % of Col. 3.
1	*Deutsche Reichsbahn.* .	1 436 300	*892 492*	14 364	*8 926*	1
2	*Danish State Rys.* . .	67 524	*41 958*	1 369	*851*	2
3	*Swiss Federal Rys.* . .	92 583	*57 529*	244	*152*	1/4

Even before January 1934, the Deutsche Reichsbahn ran trains whose speed between two stops exceeded 96 km./h. (60 m.p.h.). The growth of such express train services is shown below :

1	3	3		4	
Serial number.	Services worked by	Distance covered daily by high-speed trains of the Deutsche Reichsbahn, at speeds of 96 km. (60 miles) an hour and over			
		1 January 1934.		1 July 1938.	
		Km.	*Miles.*	Km.	*Miles.*
1	High-speed railcars	600	*373*	7 860	*4 884*
2	Steam traction	1 200	*746*	6 000	*3 728*
3	Electric traction	...	...	500	*311*
4	Together :	1 800 daily.	*1 119*	14 360 daily.	*8 923*

Table 3 gives examples of the speeding up of other express trains on the Railways who replied to this question. The average time saving on the journey is from 9 to 12 %; in certain cases it reaches 25 %.

In the case of local trains as well, most of the Railways have systematically speeded up their services by means of the measures listed above. Obviously, stops are rarely cancelled in the latter cases. Table 4 gives some of the local trains on the Reichsbahn and the Swiss Federal Rys., showing approximately the extent such trains have been speeded up by these two Administrations.

The average increase in the speed of all the passenger trains on the German Reichsbahn is shown in the table at the foot of this page for each of the different categories of trains.

The capacity of the lines has not been changed by the speeding up of the passenger trains on the Bulgarian, Danish, Norwegian, and Swedish State Railways. This also applies to the Swiss Federal Rys., though here on certain lines it has been necessary to modify and adapt the timetables of the goods trains and optional trains to suit the high-speed passenger trains.

The capacity of the Reichsbahn's lines has not decreased in so far as it has

1	2	3		4		5		6	
Serial number.	Class of train.	Average hourly train speed between two stops.							
		1914		1932		1934		1938	
		km.	*miles.*	km.	*miles.*	km.	*miles.*	km.	*miles.*
1	Express trains	65	*40.4*	68.2	*42.4*	73	*45.4*	73.4	*45.6*
2	Semi-express trains . . .	58	*36.0*	58.8	*36.5*	62.3	*38.7*	65.5	*40.7*
3	Local trains	...	...	39.4	*24.5*	43.0	*26.7*	44.3	*27.5*
4	All passenger trains . . .	...	...	45.2	*28.1*	48.9	*30.4*	49.2	*30.6*

TABLE 3.

Examples of express train acceleration.

1	2	3 - 4	5		6	7	8	9	10	11		12	
Serial number.	Train number.	RUNS.	Distance		Number of intermediate stops.		Time spent			Hourly commercial speed.			
			km.	*miles.*	1-1-34	1-7-38	Jan., 1934. Mins.	July, 1938. Mins.	Gain, %.	Jan., 1934 km.	Jan., 1934 *miles.*	July 1938 km.	July 1938 *miles.*
		I. Deutsche Reichsbahn.											
1	FD 80	Berlin Zoo.-Nuremberg . . .	476	*295.8*	1	1	361	357	1.1	79.0	*49.1*	80.0	*49.7*
2	50	Do. . . .	476	*295.8*	8	10	433	427	1.4	65.8	*40.9*	66.8	*41.5*
3	4	Berlin Zoo.-Cologne	549	*341.1*	8	8	451	442	2.0	73.2	*45.5*	74.6	*46.3*
4	L 12	Do.	551	*342.4*	4	4	420	391	6.9	78.7	*48.9*	84.6	*52.6*
5	FD 22	Do.	579	*359.8*	6	8	425	396	6.8	82.0	*51.0*	88.0	*54.7*
6	FD 6	Berlin Anh.-Frankfort (M.). .	539	*334.9*	2	3	408	386	5.4	79.1	*49.2*	83.7	*52.0*
7	44	Do. . .	539	*334.9*	10	6	479	408	14.8	67.5	*41.9*	79.2	*49.2*
8	92	Altona-Münster-Cologne . . .	457	*284.0*	16	16	470	442	6.0	58.3	*36.2*	62.0	*38.5*
9	FD 102	Cologne-Basle DR	524	*325.6*	5	6	376	340	9.6	83.5	*51.9*	92.5	*57.5*
10	137	Saarbrücken-Frankfort (M.) .	210	*130.5*	11	4	225	174	22.3	56.0	*34.8*	72.4	*45.0*
11	156	Berlin-Ratisbon-Vienna . . .	926	*575.4*	10	12	963	926	3.8	57.8	*35.9*	60.0	*37.3*
12	41	Basle-Frankfort (M.)-Berlin .	876	*544.3*	20	12	932	740	20.6	56.4	*35.0*	71.0	*44.1*
13	13	Berlin-Stralsund-Sassnitz . . Bridge instead of Stralsund route.	292	*181.4*	8	4	309	258	16.5	56.7	*35.2*	68.0	*42.2*
14	17	Berlin-Stralsund-Sassnitz . .	292	*181.4*	7	7	290	250	13.8	60.3	*37.5*	70.0	*43.5*
15	23	Berlin-Stettin.	135	*83.9*	2	0	110	95	13.6	73.7	*45.8*	85.3	*53.0*
16	24	Stettin-Berlin.	135	*83.9*	3	0	118	97	17.8	68.8	*42.8*	83.6	*51.9*
17	1	Berlin-Schneidemühl	247	*153.5*	3	0	207	167	19.3	71.5	*44.4*	88.5	*55.0*
18	7	Do.	247	*153.5*	3	1	187	170	9.1	79.0	*49.1*	87.2	*54.2*
19	31	Berlin-Breslau	341	*211.9*	5	5	266	252	5.3	77.0	*47.8*	81.2	*50.5*
20	37	Do.	341	*211.9*	5	5	271	261	8.7	75.5	*46.9*	78.5	*48.8*
21	191	Berlin-Hirschberg-Breslau . .	412	*256.0*	20	18	428	412	3.7	57.7	*35.9*	60.0	*37.3*
22	129	Breslau-Hirschberg-Berlin . .	412	*256.0*	17	14	433	380	12.2	57.0	*35.4*	65.0	*40.4*
23	64	Berlin-Dresden	180	*111.9*	5	4	149	142	4.7	72.6	*45.1*	76.2	*47.4*
24	62	Do.	192	*119.3*	3	3	156	147	5.8	73.8	*45.9*	78.5	*48.8*
25	52	Do.	180	*111.9*	4	4	157	140	10.8	68.7	*42.7*	77.0	*47.9*
26	18	Berlin-Kassel.	371	*230.5*	10	10	375	361	3.8	59.5	*37.0*	61.7	*38.3*
27	75	Kassel-Altona	360	*223.7*	12	12	403	378	6.2	53.5	*33.2*	57.0	*35.4*
28	73	Do.	360	*223.7*	14	12	378	353	6.2	57.0	*35.4*	61.0	*37.9*
29	192	Altona-Kassel	360	*223.7*	5	4	342	309	9.6	63.0	*39.1*	69.7	*43.3*
30	74	Do.	360	*223.7*	15	13	406	365	10.0	53.2	*33.1*	59.2	*36.8*

TABLE 3 *(Continued).*

Examples of express train acceleration.

2	3 - 4	5		6	7	8	9	10	11		12	
Train number.	RUNS.	Distance		Number of intermediate stops.		Time spent			Hourly commercial speed.			
		km.	*miles.*	1-1-34	1-7-38	Jan., 1934. Mins.	July, 1938. Mins.	Gain, %.	Jan., 1934 km.	Jan., 1934 *miles.*	July, 1938 km.	July, 1938 *miles.*
II. Bulgarian State Railways.												
12	Sofia-Burgas	449	*279.0*	27	26	660	625	5.3	41.0	*25.5*	43.0	*26.7*
13	Burgas-Sofia	449	*279.0*	38	30	745	648	13.0	36.2	*22.5*	41.6	*25.9*
21	Sofia-Varna	541	*336.2*	31	19	800	684	14.5	40.6	*25.2*	47.5	*29.5*
23	Varna-Sofia	541	*336.2*	26	18	785	660	16.0	41.3	*25.7*	49.2	*30.6*
2/714	Sofia-Doupnitza	90.7	*56.4*	16	5	175	125	28.6	31.0	*19.3*	43.5	*27.0*
1/88 91/810	Lovetch-Svichtov	94.8	*58.9*	12	11	221	150	32.0	25.8	*16.0*	38.0	*23.6*
III. Danish State Railways.												
Steam tr.	Copenhagen-Aalborg (Acceleration due to use of bridge instead of Strib-Fredericia ferry.)	475	*295.2*	14	14	635	585	8.5	45.0	*28.0*	49.0	*30.4*
	Copenhagen-Gedser. (Masnedo-Orehoved ferry replaced by bridge.)	170	*105.6*	2	3	184	147	25.0	55.4	*34.4*	70.0	*43.5*
IV. Norwegian State Railways.												
	Oslo-Bergen (day express) Steepest gradient 1 in 44, many curves 9 1/2 — 12 1/2 ch. radius.	492	*305.7*	42	34	748	690	8.9	39.5	*24.5*	43.0	*26.7*
	Oslo-Bergen (night express)	492	*305.7*	17	17	650	630	3.2	45.4	*28.2*	47.0	*29.2*
21 km. (13 miles) elecr.	Oslo-Trondheim (day express) Steepest gradient 1 in 55 1/2, curves 12 1/2 ch. radius.	553	*343.6*	46	36	855	721	18.6	39.0	*24.2*	46.0	*28.6*
	Oslo-Trondheim (night express)	553	*343.6*	17	17	705	640	10.0	47.2	*29.3*	52.0	*32.3*
etric save km. (10 es) steam.	Oslo-Brevik Steepest gradient 1 in 53, curves 12 1/2 ch.radius.	203	*126.1*	32	27	387	285	35.0	31.5	*19.6*	43.0	*26.7*
V. Swedish State Railways.												
Electric tr.	Stockholm C.-Malmö C.	599	*372.2*	15	6	562	478	15.0	64.0	*39.8*	75.2	*46.7*
	Malmö C.-Stockholm	599	*372.2*	15	12	567	493	13.0	63.3	*39.3*	72.9	*45.3*
	Göteborg-Malmö	299	*185.8*	13	12	340	282	17.0	52.7	*32.7*	63.6	*39.5*
	Malmö-Göteborg	299	*185.8*	12	11	335	273	18.5	53.5	*33.2*	65.7	*40.8*
	Stockholm-Ånge	484	*300.8*	9	5	507	394	22.3	57.4	*35.7*	73.7	*45.8*

TABLE 3 *(Continued).*

Examples of express train acceleration.

1	2	3 - 4	5		6	7	8	9	10	11		12	
Serial number.	Train number.	RUNS.	Distance		Number of intermediate stops.		Time spent			Hourly commercial speed.			
										Jan., 1934		July 1938	
			km.	*miles.*	1-1-34	1-7-38	Jan., 1934. Mins.	July, 1938. Mins.	Gain, %.	km.	*miles.*	km.	*m*
49	Electric tr.	Ånge-Stockholm	484	*300.8*	11	7	519	388	25.3	56.0	*34.8*	74.8	
50		Ånge-Boden	660	*410.1*	39	7	804	699	13.0	49.4	*30.7*	56.7	
51		Boden-Ange	660	*410.1*	41	9	853	721	15.5	46.5	*29.0*	54.9	
52		Boden-Riksgränsen	397	*246.7*	37	9	472	354	25.0	50.4	*31.3*	67.3	
53		Riksgränsen-Boden	397	*246.7*	37	9	468	353	24.4	50.8	*31.6*	67.5	
54		Malmö-Riksgränsen	1 991	*1 242.7*	...	...	2 579	1 981	23.2	46.5	*28.9*	60.3	
55		Riksgränsen-Malmö	1 991	*1 242.7*	...	...	2 669	1 935	27.5	44.8	*27.8*	61.7	
		VI. Swiss Federal Railways.											
56	4	Bern-Lausanne	98	*60.9*	5	4	97	93	4.1	60.5	*37.6*	63.2	
57	8	Bern-Geneva	159	*98.8*	7	7	157	146	7.0	60.5	*37.6*	65.5	
58	12	Do.	159	*98.8*	3	3	150	137	8.6	63.6	*39.5*	70.0	
59	18	Do.	159	*98.8*	6	6	157	143	8.9	61.0	*37.9*	67.0	
60	7	Geneva-Bern	159	*98.8*	7	7	165	158	4.2	58.0	*36.0*	60.5	
61	13	Do.	159	*98.8*	2	2	144	133	7.6	66.0	*41.0*	72.0	
62	17	Do.	159	*98.8*	4	4	156	140	10.3	61.0	*37.9*	68.3	
63	25	Do.	159	*98.8*	7	7	161	148	8.0	59.3	*36.8*	64.7	
64	S 0	Lausanne-Domodossola	187	*116.2*	4	4	176	165	6.3	63.8	*39.6*	68.0	
65	38	Lausanne-Brig	146	*90.7*	11	11	150	144	4.0	58.5	*36.4*	61.0	
66	44	Do.	146	*90.7*	12	12	158	148	6.3	55.4	*34.4*	59.3	
67	33	Brig-Lausanne	146	*90.7*	11	11	157	139	11.4	56.0	*34.8*	63.0	
68	37	Domodossola-Lausanne	187	*116.2*	15	12	233	194	16.7	48.2	*30.0*	58.0	
69	39	Brig-Lausanne	146	*90.7*	18	18	185	163	11.9	47.3	*29.4*	53.6	
70	45	Domodossola-Lausanne	187	*116.2*	5	6	185	173	6.5	60.8	*37.8*	65.0	
71	0 S	Do.	187	*116.2*	4	4	178	169	6.2	63.0	*39.1*	66.3	
72	103	Geneva-Olten	222	*138.0*	8	9	207	192	7.2	64.4	*40.0*	69.3	
73	107	Do.	222	*138.0*	6	6	208	201	3.3	64.0	*39.8*	66.3	
74	113	Do.	222	*138.0*	7	7	215	203	5.6	62.0	*38.5*	65.6	
75	117	Geneva-Zürich	285	*177.1*	9	9	281	266	5.3	61.0	*37.9*	64.2	
76	125	Do.	285	*177.1*	9	9	286	271	5.3	60.0	*37.3*	63.0	
77	104	Biel-Lausanne	103	*64.0*	4	4	97	93	4.1	63.5	*39.4*	66.5	
78	108	Zürich-Geneva	285	*177.1*	9	9	278	270	2.9	61.5	*38.2*	63.3	
79	112	Do.	285	*177.1*	8	10	266	257	3.4	64.5	*40.1*	66.6	
80	118	Olten-Geneva	222	*138.0*	5	5	205	193	5.8	64.7	*40.2*	69.0	

TABLE 3 *(Continued).*

Examples of express train acceleration.

2	3 - 4	5		6	7	8	9	10	11		12	
Train number.	RUNS.	Distance		Number of intermediate stops.		Time spent.			Hourly commercial speed.			
		km.	*miles.*	1-34	1-38	Jan., 1934. Mins.	July, 1938. Mins.	Gain, %.	Jan., 1934 km.	Jan., 1934 *miles.*	July, 1938 km.	July, 1938 *miles.*
122	Zürich-Geneva	285	*177.1*	13	13	290	274	5.5	59.0	*36.7*	62.5	*38.8*
439	Biel—Chaux-de-Fonds.	44	*27.3*	9	3	79	53	33.0	33.5	*20.8*	50.0	*31.1*
54	Basle-Chiasso.	320	*198.8*	6	6	339	298	12.1	56.7	*35.2*	64.2	*39.9*
56	Do.	320	*198.8*	10	10	367	354	3.5	52.2	*32.4*	54.3	*33.7*
60	Do.	320	*198.8*	18	18	378	357	5.6	50.8	*31.6*	53.7	*33.4*
153	Chiasso-Zürich	254	*157.8*	15	15	290	274	5.5	52.7	*32.7*	55.6	*34.5*
65	Chiasso-Basle.	320	*198.8*	12	12	368	332	9.8	52.0	*32.3*	57.8	*35.9*
69	Do.	320	*198.8*	11	11	362	352	2.8	53.0	*32.9*	54.5	*33.9*
71	Do.	320	*198.8*	5	5	328	291	11.3	58.6	*36.4*	66.0	*41.0*
9	Bern-Zürich	130	*80.8*	2	2	120	111	7.5	65.0	*40.4*	70.2	*43.6*
18	Zürich-Bern	130	*80.8*	3	3	123	119	3.3	63.5	*39.4*	65.6	*40.8*
22	Do.	130	*80.8*	7	7	142	132	7.0	55.0	*34.2*	59.2	*36.8*
368	Bern-Lucerne	96	*59.7*	3	3	105	86	18.0	55.0	*34.2*	67.0	*41.6*
353	Lucerne-Bern	96	*59.7*	2	2	104	83	20.0	55.3	*34.4*	69.5	*43.2*
199	Zürich-Chur	117	*72.7*	21	26	170	150	11.8	41.3	*25.7*	47.0	*29.2*
78	Buchs-Basle	196	*121.8*	2	2	185	177	4.3	63.5	*39.4*	66.2	*41.1*
196	Chur-Zürich	117	*72.7*	7	7	134	123	8.2	52.4	*32.6*	57.0	*35.4*
178	Do.	117	*72.7*	23	8	182	107	41.0	38.4	*23.9*	65.5	*40.7*
1	Zürich-St. Margrethen	111	*69.0*	5	5	123	101	17.8	54.2	*33.7*	66.0	*41.0*
17	St. Gallen-Alstätten	39	*24.2*	11	11	77	63	18.2	30.4	*18.9*	37.0	*23.0*
407	Winterthur-Romanshorn	56	*34.8*	4	4	57	51	10.5	59.0	*36.7*	66.0	*41.0*
417	Do.	56	*34.8*	15	15	89	81	9.0	37.8	*23.5*	41.4	*25.7*
	VII. **Hungarian State Railways.**											
Steam.	Budapest-Miskolc	183.9	*114.3*	10	4	181	137	24.2	61.0	*37.9*	80.5	*50.0*
Railcars.	Budapest-Hegyeshalom	187.6	*116.6*	3	1	156	123	21.2	72.0	*44.7*	91.0	*56.5*
	Budapest-Csap	341.3	*212.0*	31	13	373	261	30.0	55.0	*34.2*	78.5	*48.8*
	Budapest-Pucs	236.8	*147.2*	15	6	257	178	30.6	55.3	*34.4*	80.0	*49.7*

been possible to accelerate all the trains of a line to the same extent.

In many cases, especially when fast railcar services were introduced, it was found necessary to modify the time-tables of the goods trains, which sometimes involved changing the points at which the trains passed one another.

TABLE 4.

Acceleration of local passenger trains due to increased running speeds or shorter stops.

1	2	3 - 4	5		6	7	8	9	10	11	12	13	14		15		16
Serial number.	Train number.	Run.	Distance		Stops: Number.		Stops: Time.		Journey time.		Gain of journey time.		Hourly train speed: 1934		Hourly train speed: 1938		Remarks.
			km.	*miles.*	Jan. 1934	July 1938	Jan. 1934 min.	July 1938 min.	Jan. 1934 min.	July 1938 min.	Col. 10 - Col. 11 min.	Col. 12 × 100 / Col. 10 %	km.	*miles.*	km.	*miles.*	
		I. Deutsche Reichsbahn.															
		(a) Main lines.															
1	1024	Hof-Ratisbon	179.3	*111.4*	32	32	100	91	374	312	62	16.6	28.8	*17.9*	34.5	*21.4*	
2	323	Berlin-Stralsund . . .	241.1	*149.8*	35	35	82	64	355	320	35	9.9	40.8	*25.4*	45.2	*28.1*	
3	763	Hanover-Lehrte-Uelzen-Hamburg.	178.5	*110.9*	28	28	59	56	278	262	16	5.8	38.7	*24.0*	41	*25.5*	
4	241	Dt Eylau-Insterburg. .	206.9	*128.6*	26	26	52	48	315	279	36	11.4	39.4	*24.5*	44.5	*27.7*	
		(b) Branch lines.															
5	Aver. all trains.	Münchberg-Selbitz (RBD Ratisbon)	19.5	*12.1*	6	6	8	7	42	34	8	19.0	28.0	*17.4*	34.5	*21.4*	Max. speed 25-31 m.p.h.
6	...	Olpe-Kirchen (RBD Wuppertal).	33.6	*20.9*	9	9	7	7	66	57	9	13.7	30.5	*19.0*	35.4	*22.0*	Do.
7	...	Tilsit-Stallupönen (RBD Königsberg)	76.2	*47.3*	14	14	14	14	126	115	11	8.7	36.3	*22.6*	39.6	*24.6*	Max. speed 31-37.5 m.p.h.
8	...	Löwenberg-Sagan (RBD Breslau)	72.1	*44.8*	18	18	20	20	124	116	8	6.5	34.8	*21.6*	37.2	*23.1*	Do.
9	...	Munich East-Kreuzstrasse.	30.1	*18.7*	11	11	11	11	72	61	11	15.3	25.2	*15.7*	29.6	*18.4*	Max. speed 25-37.5 m.p.h.

TABLE 4. *(Continued).*

Acceleration of local passenger trains due to increased running speeds or shorter stops.

1	2	3-4	5		6	7	8	9	10	11	12	13	14		15		16
Serial number.	Train number.	Run.	Distance		Stops Number.		Stops Time.		Journey time.		Gain of journey time.		Hourly train speed 1934		Hourly train speed 1938		Remarks.
			km.	*miles.*	Jan. 1934	July 1938	Jan. 1934 min.	July 1938 min.	Jan. 1934 min.	July 1938 min.	Col. 10 - Col. 11 min.	Col. 12×100 / Col. 10 %	km.	*miles.*	km.	*miles.*	
		II. Swiss Federal Railways.															
10	1050	Lausanne-Geneva . . .	60	*37.3*	30	30	...	...	107	91	16	15.0	33.6	*20.9*	39.5	*24.5*	
11	509	Lausanne-Bern	97	*60.3*	23	23	...	...	163	141	22	13.5	35.6	*22.1*	41.2	*25.6*	
12	1390	Lausanne-St. Maurice .	52	*32.3*	20	20	...	...	103	83	20	19.4	30.6	*19.0*	37.6	*23.4*	
13	1365	Brig-Lausanne	146	*90.7*	36	36	...	...	226	206	20	8.9	38.8	*24.1*	42.5	*26.4*	
14	1526	Neuchâtel-Lausanne . .	74	*46.0*	18	18	...	...	117	100	17	14.5	38.0	*23.6*	44.3	*27.5*	
15	1466	Lyss-Lausanne	100	*62.1*	26	26	...	...	195	176	19	9.7	30.7	*19.1*	34.0	*21.1*	
16	2447	Lucerne-Basle	95	*59.0*	23	23	..	...	176	159	17	9.7	32.4	*20.1*	35.8	*22.2*	
17	2542	Bellinzona-Chiasso. . .	55	*34.2*	11	11	...	...	115	67	48	41.7	28.6	*17.8*	49.2	*30.6*	
18	2253	Olten-Zürich	63	*39.1*	16	16	...	...	107	81	26	24.2	35.4	*22.0*	44.8	*27.8*	
19	2279	»	63	*39.1*	15	15	...	...	122	98	24	19.8	31.2	*19.4*	38.6	*24.0*	
20	2780	Aarau-Arth-Goldau . .	63	*39.1*	15	15	...	...	107	80	27	25.2	35.2	*21.9*	47.3	*29.4*	
21	2680	Bern.Lucerne.	96	*59.7*	19	19	...	...	172	152	20	11.6	33.6	*20.9*	38.0	*23.6*	
22	3333	Zürich-Chur	117	*72.7*	33	33	...	...	231	178	53	23.0	30.4	*18.9*	39.2	*24.4*	
23	3431	Zürich-Sinthal	88	*54.7*	33	33	...	...	212	176	36	17.0	25.0	*15.5*	30.0	*18.6*	
24	3161	Stein-Säck.—Winterthur	74	*46.0*	20	21	...	...	152	126	26	17.1	29.2	*18.1*	35.2	*21.9*	
		III. Swedish Private Railways.															
25	...	Galiuflad-Nässjö . . .	196	*121.8*	26	8	...	...	240	164	74	30.8	49.0	*30.4*	72.0	*44.7*	
26	...	Mellerue-Arvika. . . .	163	*101.3*	34	34	...	...	275	240	35	12.7	35.6	*22.1*	39.9	*24.8*	

This caused a slight reduction in the total capacity of certain lines. In some cases also it was found necessary to cancel the timetables for goods trains and optional trains altogether. In most cases, however, it was possible to get out new timetables for these trains, so that the total capacity of the lines could be maintained.

II. — Consideration of the methods likely to speed up passenger trains.

1. Eliminating or shortening stops.

In endeavouring to increase the average speed of express trains, nearly all the Companies have made full use of the possibilities of cutting out some stops

TABLE 5.

Time-table for train D 41, Basle-Berlin.

Distance covered : 876 km. *(544 miles).*

1	2		3	4	5		6	7
Stations.	1 January 1934.				1 July 1938.			
	Stops.				Stops.			
	Arr.	Dep.	Number	Time min	Arr.	Dep.	Number.	Time min.
Basle		11.57 p.m.				12.30 a.m.		
Mülheim	12.27	12.29 a.m.	1	2	12.58	12.59 a.m.	1	1
Freiburg	12.56	1.02 a.m.	1	6	1.24	1.28 a.m.	1	4
Emmendingen	1.19 a.m.		1	1	1.41 a.m.		1	1
Lahr-Dinglingen	1.45 a.m.		1	1		...	...	...
Offenburg	2.04	2.15 a.m.	1	11	2.16	2.21 a.m.	1	5
Appenweier	2.41 a.m.		1	1		...	...	...
Baden-Oos	2.51	2.53 a.m.	1	2	2.50	2.52 a.m.	1	2
Rastatt	3.02	3.04 a.m.	1	2		...	...	...
Karlsruhe	3.24	3.38 a.m.	1	14	3.18	3.34 a.m.	1	16
Mannheim	4.30	4.40 a.m.	1	10	4.20	4.28 a.m.	1	8
Frankfort (Main)	6.20	7.00 a.m.	1	40	5.32	5.50 a.m.	1	18
Bebra	9.52	10.4 a.m.	1	12		...	...	...
Eisenach	10.44	10.47 a.m.	1	3		...	..	...
Gotha	11.15	11.19 a.m.	1	4		...	...	...
Erfurt	11.40	11.45 a.m.	1	5	9.15	9.21 a.m.	1	6
Weimar	12.7	12.9 p.m.	1	2	9.41	9.42 a.m.	1	1
Weissenfels	12.49	1.00 p.m.	1	11	10.25	10.26 a.m.	1	1
Halle (Saale)	1.28	1.33 p.m.	1	5	10.51	10.59 a.m.	1	8
Bitterfeld	1.56 p.m.		1	1		...	...	...
Berlin Anh. Bf.	3.29 p.m.				12.50 p.m.			
Total.	15 h. 32 m. = 932 minutes.		19	133	12 h. 20 m. = 740 minutes.		12	71
Commercial speed.	$V_R = \frac{876 \times 60}{932} = 56.2$ km./h. = *34.9 m. p. h.*				$V_R = \frac{876 \times 60}{740} = 71$ km./h. = *44.1 m. p. h.*			

TABLE 6.

Time-table for train D 137, Saarbrücken-Frankfort (Main).

Distance covered : 210 km. *(130.5 miles).*

1	2		3	4	5		6	7
Stations.	1 July 1938.				1 January 1934.			
	Stops.				Stops.			
	Arr.	Dep.	Number.	Time min.	Arr.	Dep.	Number.	Time min.
Saarbrücken. . .		6.00 a.m.						
Neunkirchen. . .	6.22	6.23 a.m.	1	1	6.51	6.52 a.m.	1	1
St. Wendel . . .	6.39 a.m.		1	1		...	...	...
Türkismühle. . .	6.57	7.00 a.m.	1	3		...	...	...
Idar-Oberstein . .	7.34	7.35 a.m.	1	1	7.39	7.40 a.m.	1	1
Kirn	7.48 a.m.		1	1		...	...	. .
Sobernheim . . .	8.18 a.m.		1	1		...	...	...
Kreusnach . . .	8.24 a.m.		1	1	8.19	8.20 a.m.	1	1
Bingerbrück. . .	8.40	8.45 a.m.	1	5		...	...	...
Bingen.	8.49 a.m.		1	1		...	...	...
Mainz	9.11	9.13 a.m.	1	2	8.51	8.53 a.m.	1	2
Frankfort (Main)	9.45 a.m.				9.24 a.m.			
Total. . .	3 h. 45 m. = 225 minutes.		11	18	2 h. 54 m. = 174 minutes.		4	5
Train speed. . .	$V_R = \frac{210 \times 60}{225} = 56$ km./h. = *34.8 m. p. h.*				$V_R = \frac{210 \times 60}{174} = 72.2$ km./h. = *44.9 m. p. h.*			

completely or at least shortening them very considerably. The results obtained by the Deutsche Reichsbahn are brought out in a striking way in Tables 5 and 6, in which the timetables for trains D41 from Basle to Berlin, and D137 from Sarrebrück to Frankfort (Main), in 1934 and 1938, are contrasted.

The extent to which stops have been suppressed in the case of certain trains is shown in Table 3 (for the German Reichsbahn, lines 7, 12, 13, 16, 17 and 22; for the Norwegian State Rys., lines 39, 41 and 43; for the Swedish State Rys., lines 44 to 53; for the Swiss Federal Rys., lines 82 and 98; for the Hungarian State Rys., lines 103 to 106; and in Table 4, line 25, for the Halmstadt-Nässjö Private Railway (Sweden).

2. Lightening of the trains.

The use of this method of speeding up passenger trains can be considered in two ways. If a lighter construction be adopted for the different vehicles, the load hauled is reduced, while the number of vehicles remains the same, or else the load to be hauled can be reduced by making up the train with fewer vehicles of the usual type.

The Deutsche Reichsbahn and the Swiss Federal Rys. have used both solutions as much as possible. For example, whereas the stock for the German

D trains (express corridor stock) built prior to 1934 weighed about 48 t. (47.2 Engl. tons) the weight of the vehicles put into service since 1935 has been reduced to about 39 t. (38.4 Engl. tons) with the same number of seats and same interior arrangement. This result has been obtained by welding instead of rivetting. In the 1939 type of vehicles for D trains, the weight has been still further reduced to about 28 t. (27.55 Engl. tons).

The Bulgarian State Rys. and Hungarian State Rys. have not reduced the weight of their trains in order to speed up their passenger services. On the other hand, nearly all Railways, when building new railcars, have endeavoured to obtain sets of moderate weight by using lightened construction.

As an example of the reduction of the weight of the trains with existing stock, i. e. by using shorter trains, in order to speed them up systematically, we may quote the express services in the Ruhr District on the Reichsbahn. The nomenclature « Ruhr express service » applies to the short local trains running in the Ruhr District between the express trains and semi-express trains at frequent and regular intervals — as far as possible to a fixed timetable — for the regional interurban traffic. Along the 83-km. (51.6 miles) centre line of this District with a population of about 4.2 millions, seven large towns with over 100 000 inhabitants each are situated, between Duisburg and Hamm. In the place of the former local trains at long intervals, which were very long trains often making long stops at junctions to give the necessary connections, and for technical reasons could not be run at the most favourable times for the regional traffic, small units are now run, consisting of three or four carriages which can be hauled by a lighter steam locomotive at a higher speed. The short length of these trains greatly facilitates the various operations at the departure plat-

TABLE 7.

Acceleration of local passenger trains due to decreased train weight.

(on a few of the main sections having fast local train services in the Ruhr District).

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Serial number.	Run from	Run to	Distance km.	Distance miles.	Discontinued local trains. Number of trains per day.	Discontinued local trains. Weight with locom. Metr. tons.	Discontinued local trains. Weight with locom. Engl. tons.	Discontinued local trains. Journey time min.	Discontinued local trains. Hourly comm. speed. km.	Discontinued local trains. Hourly comm. speed. miles.	Fast local services in the Ruhr District, 1938. Number of trains per day.	Fast local services in the Ruhr District, 1938. Weight with locom. Metr. tons.	Fast local services in the Ruhr District, 1938. Weight with locom. Engl. tons.	Fast local services in the Ruhr District, 1938. Journey time min.	Fast local services in the Ruhr District, 1938. Hourly comm. speed. km.	Fast local services in the Ruhr District, 1938. Hourly comm. speed. miles.	Fast local services in the Ruhr District, 1938. Weight reduction, %.	Fast local services in the Ruhr District, 1938. Gain in journey time. %
1	Duisburg. . .	Essen	20	12.4	8	285	280.5	27	44	27.3	...	235	231.3	25	48	29.8	21	7.5
2	Duisburg. . .	Essen H.-Dortmund.	54	33.6	6	335	329.7	89	36	22.4	51	295	231.3	68	48	29.8	42	31
3	Dortmund . .	Hamm. . . .	29	18.0	1	335	329.7	46	38	23.6	31	235	231.3	36	48	29.8	21	28
4	Duisburg. . .	Gelsenkirchen-Dortmund.	56	34.8	10	335	329.7	80	42	26.1	73	235	231.3	64	52	32.3	42	25
5	Gelsenkirchen .	Dortmund . .	30	18.6	3	285	280.5	35	51	31.7	...	235	231.3	34	53	32.9	21	3
6	Wanne-Eickel .	Dortmund . .	25	15.5	7	285	280.5	28	54	33.6	6	235	231.3	27	56	34.8	21	4

forms. Notices inscribed « Ruhr-Schnellverkehr » request passengers to enter and leave the trains as quickly as possible, so that in general only 30 seconds are required for each stop. Table 7 shows how the weight of the trains has been reduced and how much time has been saved for some of the main accelerated Ruhr services, which, for the years 1933, 1935 and 1938, represented the following train mileages :

Year.	Millions of	
	train-km.	*train-miles.*
1933	1.3	*0.81*
1935	8.0	*4.97*
1938	8.5	*5.28*

3. Better utilisation of the existing tractive power.

The acceleration of the trains by better utilisation of the existing tractive power can be achieved by getting more work from the boiler, the maximum permissible speed on the line either remaining the same or being increased. Some Reichsbahn trains on which the existing tractive power has been taken advantage of for speeding up the trains, without increasing the maximum speed on the line, are given in the table at the foot of this page.

Speeding up passenger trains by increasing the maximum permissible speed has been used by the Reichsbahn above all on its secondary lines. Between 1934 and 1938, the maximum speed was increased :

— from 40 to 60 km./h. (25 to 37.3 m.p.h.) on 3 488 km. (2 167 miles) of secondary lines;

— from 40 to 50 km./h. (25 to 31 m.p.h.) on 2 255 km. ((1 391 miles) of secondary lines; and

— from 50 to 60 km./h. (31 to 373 m.p.h.) on 3 512 km. (2 182 miles) of secondary lines,

— i. e. on a total of 9 255 km. (5 150 miles) of secondary lines.

Various examples are given in Table 4, lines 5 to 9.

The Danish State Rys. have increased the maximum speed on the main lines from 100 to 120 km./h. (62 to 75 m.p.h.),

1	2	3	4	5	6	7	8	9	10
Serial number.	Description.	D 13		D 14		D 156		D 185	
		1934	1938	1934	1938	1934	1938	1934	1938
1	Class of locomotive	03	03	03	03	01	01	01	01
2	Normal load . . . { Metr. t. / *Engl. t.*	550 / *541*	550 / *541*	550 / *541*	550 / *541*	400 / *394*	400 / *394*	500 / *492*	500 / *492*
3	Distance covered . { km. / *miles*	241 / *150*	241 / *150*	241 / *150*	241 / *150*	632 / *393*	632 / *393*	758 / *471*	777 / *483*
4	Time spent on non-stop run, mins.	196	187	199	191	529	514	647	625
5	Average hourly train speed. { km. / *miles*	73.7 / *46.0*	77.2 / *48.0*	72.6 / *45.1*	75.6 / *47.0*	71.7 / *44.5*	74.0 / *46.0*	70.3 / *43.7*	74.6 / *46.6*

and on most of their secondary lines from 45 to 75 km./h. (28 to 43.5 m.p.h.).

The Hungarian State Rys. have increased the maximum speed for railcars on the branch lines from 40-45 km./h. (25-28 m.p.h.) to 55-60 km./h. (34-37.3 m.p.h.).

The Swiss Federal Rys. have authorised a maximum speed of 125 km./h. (77.7 m.p.h.) instead of 100 km./h. (62 m.p.h.) for the electric motor coaches and diesel-electric railcars, and 125 km. instead of 110 km./h. (68.3 m.p.h.) for the light high-speed trains. The Bergslagen Private Swedish Co. has raised the maximum speed for railcars to 70 km./h. (43.5 m.p.h.).

The Bulgarian and Swedish State Rys. have not given any figures of maximum speeds, which have also been raised on their systems. The Norwegian State Rys. have not raised their maximum speeds.

4. Constructional improvements to steam and electric locomotives.

According to the Deutsche Reichsbahn and the Hungarian State Rys., streamlining locomotives is an efficient method of saving power on trains running at very high speeds. Its usefulness has been recognised by the Reichsbahn after very carefully conducted trials. For example, the drawbar horse-power developed by a 4-6-2 class 03 non-streamlined express locomotive is 800 H.P., whereas that of the same locomotive, when streamlined, is 1 185 H.P. at 140 km./h. (87 m.p.h.). This large saving in power enables up to two metal coaches, each weighing 50 t. (49.2 Engl. tons), to be added to D trains at speeds of 140 km./h. It must be pointed out, however, that at lower speeds, the saving in power due to streamlining decreases, and becomes nil at the lowest speeds (starting). Consequently a train weighing 100 tons more, when hauled by the same class of locomotive, cannot be accelerated at the same rate as the shorter train hauled by the non-streamlined locomotive, and the time taken for the journey will be longer. However, with the increase in power quoted above, it is possible to add one metal coach to D trains hauled by a streamlined locomotive without increasing the journey time. It will take a little longer to accelerate this train on starting owing to the lower excess power, but at the higher speeds the gain in power of the streamlined locomotive will give this train quicker acceleration. In this case it is even possible to make a small saving on the journey time.

The good results obtained by streamlining steam locomotives have resulted in the most recent express electric locomotives being streamlined as much as possible. The running gear of electric locomotives has not been cased in, however, at it is considered essential to be able to inspect and maintain the whole of the motion very easily. The inherent power of electric locomotives is so great that they can meet practically all service requirements as regards the load to be hauled. The possibility of adding extra coaches to the trains as a result of streamlining the locomotive is consequently of no importance in this case.

In the case of motor coaches picking up current, intended to run at maximum speeds of 120 and 160 km./h. (75 and 100 m.p.h.), the front and side walls have been fitted with petticoats which come as low down as possible in order to reduce the air resistance as much as possible.

The streamlined steam locomotives of the Hungarian State Rys. develop about 830 I.H.P. at the maximum speed of 120 km./h. (75 m.p.h.).

The Swiss Federal Rys. have modified the outward form of their newest vehicles to conform with modern ideas on the effect of air resistance as far as this is necessary for speeds up to 125

km./h. (77.7 m.p.h.) They have not yet made any comparative tests.

The Bulgarian, Danish, Norwegian, and Swedish State Rys. so far have not streamlined any of their steam or electric locomotives, as the speeds practised on these lines make it unnecessary.

Mention may be made here of the tests made by the Lübeck-Büchen Ry. (taken over by the Reichsbahn some time ago) in order to speed up the passenger services between two neighbouring towns by the introduction of a special type of train. On the Hamburg-Lübeck line, steam trains of a special type were introduced, giving a similar service to railcars, and pulled by the locomotive in one direction and pushed in the other. These trains consist of a streamlined 2-4-2 locomotive developping 650 h.p. and one or two double-decker coaches. One unit of these coaches has a seating capacity of 300 in two bodies coupled together on a common Jakobs bogie. At each end there is a cabin from which the driver can drive the locomotive and look after it from a distance. With this push-and-pull double-decker train, the 64 km. (40 miles) between Hamburg and Lübeck are covered at an average speed of 94.5 km./h. (58.7 m.p.h.), the maximum speed being 120 km./h. (75 m.p.h.). The journey takes 41 minutes. The time taken by the ordinary type of steam train on the same line was 50 minutes, i.e. the average speed was 75.6 km./h. (47 m.p.h.). With similar traffic conditions, it is possible to introduce suitable special types of steam trains. Steam train operation in the guise of railcars has such great advantages, especially for traffic between important places with a dead-end station, that in the near future it is proposed to introduce other push-and-pull trains on other lines. These trains consist of eight-wheeled vehicles of the usual type, pulled or pushed by a 4-6-4 tank engine. At the end of the train opposite the locomotive there is a luggage van with a driving compartment containing the necessary remote control equipment.

Most of the electric locomotives of the Reichsbahn, intended to run at 120 km./h. (75 m.p.h.) an hour or over, have four pairs of driving wheels and a leading and trailing carrying pair. Such locomotives are usually symmetrical. From the start each carrying pair of wheels was combined with the adjacent driving pair of wheels into a Krauss-Helmholtz bogie (1 D 01 wheel arrangement), with a Krauss-Helmholtz bogie at each end, and between these bogies two driving pairs of wheels with thinned down flange and 15 mm. (19/32 in.) side play. The Krauss-Helmholtz bogies are centred by springs acting on the pivot and the carrying pairs of wheels. A fairly large number of locomotives with this wheel arrangement are under construction for maximum speeds of 120, 150 and 180 km./h. (75, 93 and 112 m.p.h.). The results obtained in service have shown that vehicles with Kraus-Helmholtz bogies are completely satisfactory even at the highest speeds. For speeds exceeding 120 km./h. (75 m.p.h.), the three following solutions have been carefully investigated, as far as the arrangement of the running gear is concerned :

1. Krauss bogie at each end; centring springs with initial symmetrical tension;

2. Krauss bogie at each end; centring spring on the trailing bogie pivot with a higher initial tension;

3. Krauss bogie at the leading end; trailing driving pair of wheels fitted rigidly in the frame; trailing carrying pair of wheels acting as a bissel truck.

Very careful measurements proved that the second arrangement was the best. The centring spring on the pivot of the trailing Krauss-Helmholtz bogie is given a higher initial tension. The initial tension is automatically regulated through the locomotive centring gear.

Passenger train acce

1	2	3	4	5		6	7	8	
Serial number.	Year of electrification.	Run.				Number of trains per day.	Position in ye (col.		
		from	to	Distance			Steam traction.		
				km.	*miles.*		Journey time, min.	Hourly spee	
								km.	*mil*
									I. Den
									(a) Express
1	1933	Augsburg. . .	Ulm	86.0	*53.4*	8	70.0	73.7	*45*
2	»	Ulm	Augsburg. . .	86.0	*53.4*	8	68.5	75.4	*45*
3	1934	Augsburg. . .	Treuchtlingen .	75.3	*46.8*	8	64.0	70.6	*43*
4	»	Treuchtlingen .	Augsburg. . .	75.3	*46.8*	8	66.9	67.5	*41*
									(b)
5	1933	Augsburg. . .	Ulm	86.0	*53.4*	17	125.0	41.3	*25*
6	»	Ulm	Augsburg. . .	86.0	*53.4*	16	121.5	42.5	*26*
7	1934	Augsburg. . .	Treuchtlingen .	75.3	*46.8*	7	88.2	51.2	*31*
8	»	Treuchtlingen .	Augsburg. . .	75.3	*46.8*	7	97.8	46.3	*28*
									II. Swe
9		Göteborg C . .	Malmö C. . .	299.0	*185.8*	...	295	60.8	*37*
10		Malmö C. . .	Göteborg C . .	299.0	*185.8*	...	295	60.8	*37*
11		Stockholm . .	Ånge	484.0	*300.8*	...	459	63.3	*39*
12		Ånge	Stockholm . .	484.0	*300.8*	...	458	63.4	*39*
									III. S
	Train No.								*(a) Ex*
13	368	Bern	Lucerne . . .	96.0	*59.7*	...	100	57.6	*35*
14	353	Lucerne . . .	Bern	96.0	*59.7*	...	101	57.2	*35*
									(b)
15	1537	Neuchâtel . .	Les Verrières .	39.0	*24.2*	...	76	30.8	*19*
16	1540	Les Verrières .	Neuchâtel . .	39.0	*24.2*	...	56	41.8	*26*
17	2680	Bern	Lucerne . . .	96.0	*59.7*	...	153	37.7	*23*
18	2665	Lucerne . . .	Bern	96.0	*59.7*	...	158	36.6	*22*
19	3518	Buchs	Rohrschach . .	50.0	*31.1*	...	67	44.8	*27*
20	3555	Rohrschach . .	Buchs	50.0	*31.1*	...	67	44.8	*27*

to electrification.

9	10		11	12		13	14		15	16
electrification regards :			Position in 1938.						Acceleration obtained by electrification in year of same (Col. 2), %	Acceleration made possible by electric traction, in 1938, %
	Electric traction.		Obtainable with steam traction.			Obtained with electric traction.				
rney ne, in.	Hourly speed		Journey time, min.	Hourly speed		Journey time, min.	Hourly speed			
	km.	*miles.*		km.	*miles.*		km.	*miles.*		
sbahn.										
express trains.										
2.0	83.2	*51.7*	58.2	88.7	*55.1*	57.0	90.5	*56.2*	12.9	2.0
0.8	86.2	*53.6*	59.2	87.2	*54.2*	58.7	87.8	*54.6*	14.3	0.7
4.6	82.8	*51.5*	57.8	78.2	*48.6*	51.0	88.6	*55.1*	17.3	13.3
7.2	79.0	*49.0*	59.6	75.8	*47.1*	52.6	86.0	*53.4*	17.0	13.4
as.										
3.0	50.1	*31.1*	115.8	44.5	*27.7*	103.0	50.1	*31.1*	21.3	12.6
0.5	51.3	*31.9*	117.1	44.0	*27.3*	108.1	47.7	*29.6*	20.7	8.4
1.0	55.8	*34.7*	85.5	53.0	*33.3*	77.2	58.5	*36.4*	8.9	9.3
0.0	56.5	*35.1*	88.8	51.0	*31.7*	77.0	58.7	*36.5*	22.0	15.1
e Railways.										
..	...	...	...	...	...	255	70.4	*43.7*	15.8	...
..	...	...	...	...	...	251	78.3	*44.4*	17.6	...
..	...	...	...	...	...	371	71.5	*48.7*	23.6	...
..	...	...	...	...	...	370	78.5	*48.8*	23.8	...
eral Railways.										
s.										
..	...	...	...	...	...	81	71.2	*44.2*	23.6	...
..	...	...	...	...	...	81	71.2	*44.2*	24.4	...
s.										
..	...	...	...	...	...	70	33.4	*20.8*	8.5	...
..	...	...	...	...	...	52	45.0	*28.0*	7.7	...
..	...	...	...	...	...	132	43.7	*27.2*	15.9	...
..	...	...	...	...	...	127	45.3	*28.1*	23.8	...
..	...	...	...	...	...	56	53.5	*33.2*	19.4	...
..	...	...	...	...	...	54	55.6	*34.5*	24.0	...

Tests are now being made to improve the running of the locomotive still further by shock absorbers on the bogie.

On the Bulgarian State Rys. the maximum speeds do not exceed 75 km./h. (46.5 m.p.h.). In view of the relatively small increase in the average speed special efforts to improve either the method of locomotive construction or operation would not have been justified. All that has been done has been to increase the heating surface and grate area in recent locomotives, and make the driving wheels 1.65 m. (5 ft. 5 in.) instead of 1.45 m. (4 ft. 9 in.) as on the old locomotives.

The other Railways state that, in the case of steam locomotives, they have made no special constructional improvements during the last few years.

On the other hand, the Swedish State Rys. state that they are building their new electric locomotives for a maximum speed of 100 km./h. (62 m.p.h.) instead of 90 (56 m.p.h.) as in the past. In order to speed up their passenger trains the Swiss Federal Rys. have increased the maximum speed of their electric locomotives from 90 to 110 km./h. (56 to 68.3 m.p.h.), and at the same time they have improved the suspension and increased the tension of the centring springs of the bogies and bissels. The cost of these alterations has amounted to 0.75 % of the capital cost of the locomotive.

5. Replacing steam traction by electric traction.

The introduction of electric traction on lines hitherto operated by steam first of all made possible considerable speeding up of passenger trains. Examples are given in Table 8, Column 15, for the Deutsche Reichsbahn, the Swedish State Rys. and the Swiss Federal Rys. Thanks to improvements made in the meantime, the steam locomotives have recovered some of the ground they lost, as is shown in Column 16 of Table 8. All the same the speeding up made possible by electrification of suitable line sections is still appreciable.

Particularly successful results have been obtained by the Reichsbahn in the case of the electrification of the Berlin Metropolitan, Circle, and suburban lines. This electrification has made it possible, in fact, to increase the maximum speed on the railway lines in and round Berlin, as shown hereafter :

— Metropolitan, from 45 to 55 km./h. (28 to 34.2 m.p.h.);

— Circle, from 45 to 65 km./h. (28 to 40.4 m.p.h.);

— Suburban, from 60 to 75 km./h. (37.3 to 46.6 m.p.h.).

As a result, the average train speed has increased :

— On the Metropolitan, from 22 to 31 km./h. (13.7 to 19.3 m.p.h.);

— On the Circle Railway, from 24 to 33 km./h. (14.9 to 20.5 m.p.h.), and

— On the suburban lines, from 30 to 35-43 km./h. (18.6 to 21.7-26.7 m.p.h.).

The train frequency on the Metropolitan, which was 24 pairs of trains per hour, has been increased, and is now 40 pairs of trains per hour. One measure which has contributed to this result to a large extent is the reduction of the clearing time (time between beginning to leave the station and clearing the starting signal), this period being reduced from 40 seconds to 25.

Table 9 gives particulars about this matter.

The Danish State Rys. have electrified the Copenhagen suburban services in the last few years, in order to speed up the trains.

The numerical data given below about the length of electrified lines at the end of

TABLE 9.

Journey times on the Berlin Metropolitan, Circle and Suburban Lines with steam and electric traction.

1	2	3	4	5
Serial number.	Run.	Journey time.		
		Steam traction, Mins.	Electric traction, Mins.	Saving, %.
1	Complete Circle	116	75	35.3
2	Potsdam-Erkner	119	88	25.6
3	Schlesischer Bahnhof-Mahlsdorf .	26	22	15.4
4	Schlesischer Bahnhof-Grünau . .	33	24	27.3
5	Berlin-Schöneweide-Spindlersfeld .	8	6	25.0
6	Schlesischer Bahnhof-Charlottenburg	32	22	31.3
	Journey times from Friedrichstrasse to :			
7	Lichtenberg-Friedrichsfelde . . .	23	18	21.7
8	Kaulsdorf	37	27	25.7
9	Karlshorst.	29	21	26.7
10	Friedrichshagen	44	33	25.0
11	Erkner	61	45	25.4
12	Grünau	43	32	25.3
13	Spandau-West.	37	31	14.2
14	Wannsee	42	31	26.2
15	Potsdam	58	43	25.2

1937 on those railways who replied to the question with which we are now dealing with are taken from the International Railway Statistics for the year 1937 :

Position as regards electrification at 31st December 1937.

1	2	3		4		5
Serial number.	Railway.	Total length of lines worked		Length of electrified lines		
		km.	*miles.*	km.	*miles.*	% of total.
1	Deutsche Reichsbahn (including Austria and Sudetic Territory)	63 873	*39 690*	3 163	*1 965*	5.0
2	Bulgarian State Rys.	3 344	*2 078*	...	...	...
3	Danish State Rys.	2 387	*1 483*	38	*24*	1.6
4	Hungarian State Rys.. . . .	7 647	*4 752*	248	*154*	3.3
5	Norvegian State Rys.. . . .	3 656	*2 272*	337	*209*	9.2
6	Swedish State Rys.	7 901	*4 910*	3 355	*2 085*	42.4
7	Swiss Federal Rys.	2 877	*1 788*	2 124	*1 320*	73.8

6. Improving the lines.

On the Reichsbahn the speeding up of passenger trains has made it necessary to increase the superelevation on curves, and consequently to alter the superelevation gradients and lengthen the transition curves. The layouts have also been revised, special attention being paid to the respective level of the two rails. In this connection it should be noted that in order to be ready for higher passenger train speeds, the Reichsbahn took the precaution of renewing many years beforehand a large part of its permanent way, so that preparatory to the speeding up of passenger trains it was only necessary to renew sections that were too old and too weak, to a very small extent.

In the same way improvements in the location of lines on which the passenger trains were to be considerably speeded up were made many years in advance, when maintaining and renewing the track. Altogether some 22 000 km. (13 670 miles) were adapted for speeds of 120 km./h. (75 m.p.h.) and over. Improvements to the layout in the last ten years have involved an expenditure of some 33 million Rm., i.e. about 1 500 Rm. per track-km. (2 400 Rm. per track-mile). In order to improve the layout in stations on these lines, operations which generally took place at the same time as the renewal of points and crossings, about 1 100 000 Rm. were spent, so that altogether the total expenditure amounted to 2 000 Rm. per track-km. (3 200 Rm. per track-mile).

The passenger services via Sassnitz-Trälleborg were considerably speeded up when the ferry-boat service between Stralsund and Rügen was replaced by the Rügen dyke.

The Danish State Rys. on their side report that the adoption of a maximum speed of 120 km./h. has made it necessary to give special attention to the track on certain lines. When in spite of this the rail joints again became low, the track was taken up and two rails welded together to make longer lengths between joints. In addition the special preparatory work involved increasing the sleepering and strengthening the ballast.

Here again the replacement of the ferry-boat services by bridges considerably speeded up the passenger trains in the case of the Strib-Fredericia and Masnedö-Orehoved services.

Wherever the maximum speed of passenger trains has been increased, the Hungarian State Rys. have systematically improved their lines according to a programme prepared beforehand. In particular the worn permanent way was removed and gravel ballast replaced by broken stone on curves and crossings.

The same Railways have made important improvements in the case of the Budapest-Hegyeshalom and Budapest-Hatvan lines on about 80 km. and 17 km. (50 and 10 1/2 miles) respectively, at a cost of 15 200 and 54 400 pengoes per track-km. (24 500 and 87 500 pengoes per track-mile) respectively.

The Swiss Federal Rys. on their side insist on the importance of a satisfactory laying of the track on curves. They state that, in their opinion, one of the steps to be taken before increasing the speed is to peg out and mark the transition points of curves very carrefully, as these points serve to assure the exact alignment and levelling up of the track and facilitate checking it at any moment. The exact laying of the track is frequently checked by trial runs with special control wagons. Wherever gravel was still used for ballast, it was replaced by broken stone.

Immediate improvements in the location of the track have only been made to a limited extent; they cost on the average 11 000 fr. per km. (17 700 fr. per mile) of single track (in Swiss currency).

On account of the expense any idea of more extensive improvements in the layout had to be given up, for example

increasing the radius of curves. Slight alterations were made on approximately half the total length of curves, in order to introduce better transitions. As this work was done at the same time as the ordinary maintenance of the track, there was no additional expenditure.

The Bulgarian, Norwegian and Swedish State Rys. did not find it necessary to take any special steps to improve their lines when speeding up their passenger trains.

The improvement of lines where the speed is to be increased also includes the laying of large radius turnouts.

On the 22 000 km. (13 670 miles) of track mentioned above, the Deutsche Reichsbahn has laid 2 500 turnouts of 500-m. (25 chains) radius, and 500 of 1 200-m. (60 chains) radius. The 500-m. radius turnouts can be run through at a speed of 60 km./h. (37.3 m.p.h.) and those of 1 200-m. radius at 100 km./h. (62 m.p.h.), or even 120 km./h. (75 m.p.h.) an hour with a suitable superelevation.

A fairly large number of these new points and crossings have been used as double-curve turnouts (curving in the same or opposite direction). Those for lines curving in the same direction are generally laid with the same cant as the corresponding running lines.

A turnout of 500-m. radius or more costs 8 000 Rm. including laying, connecting up with the signal box, etc., so that the cost per kilometre of single track was about 1 100 Rm. (1 770 Rm. per track-mile).

To enable their trains to run at increased speeds, the Danish State Rys. have adopted 1 in 14 turnouts, of 500-m. (25 chains) radius, which can be run through at 60 km./h. (37.3 m.p.h.). When superelevation is necessary on the line, the turnouts have also been laid with superelevation.

The Swiss Federal Rys. have replaced 30 turnouts which could only be run through at 40 km./h. (25 m.p.h.) by 1 in 12 turnouts, of 300-m. (15 chains) radius, which made it possible to run onto the branch line at 60 km./h. (37.3 m.p.h.). A turnout of this sort costs 4 000 Swiss francs, including the reconstruction. Since 1937 the Swiss Federal Rys. have adopted 1 in 16.6 turnouts, of 800-m. (40 chains) radius, which can be run through at 80 km. (50 m.p.h.). When both the lines of these new turnouts are run through by express trains, there is no superelevation. But if the fast or stopping trains run chiefly on the branch line and the adjacent curves are curved in the same direction, the turnout is laid in such a way that it is included in the superelevation. One of these new 1 in 16.6 turnouts costs, including reconstruction, 10 000 Swiss francs.

As regards the question whether the speeding up of passenger trains increases the cost of permanent way maintenance, very little practical information is as yet available. The Reichsbahn, however, estimates that the maintenance costs have increased by at least 20 % on account of the higher speeds. It considers that those lines which formerly only required methodical renewal every 3 years, now have to be gone over every 2 to 2 1/2 years. In addition the consumption of permanent way materials on the lines in question has increased, since renewal is necessary at shorter intervals than formerly.

When the speed does not exceed 120 km./h. (75 m.p.h.), the Reichsbahn has made no changes in the protection of level crossings. For speed of over 120 km./h., as far as possible barriers or gates operated from a distance have been replaced by gates operated on the spot; in many cases also level crossings have been eliminated and bridges or subways constructed. When it was not possible to eliminate remotely controlled level crossings, and the operation of the gates on the spot was undesirable economically, crossings of this kind are watched

TABLE 10.

Speeds on curves, superelevated sections and superelevation gradients.

1	2	3	4	5	6	7	8
Serial number.	Railway Administration.	Permissible hourly speed on curves.		Superelevation, H, in millim.			Inclination of superelevation gradient.
		Locomotives, km./h.	Railcars, km./h.	As a rule.	Maximum.	Minimum.	
1	*Deutsche Reichsbahn.*	$4.25 \times \sqrt{R}$	$4.5 \times \sqrt{R}$	$8 \times \frac{V^2}{R}$	150 mm. (*6″*)	$\frac{11.8 \times V^2}{R} - 90$	1 : 10 V as a rule. 1 : 8 V minimum.
2	*Bulgarian State Rys.*	with R = 150 to 200 m. : $3.5 \times \sqrt{R}$ with R = 200 to 550 m. : $3.8 \times \sqrt{R}$	10 % higher than in Col. 3.	$8.5 \times \frac{V^2}{R}$	130 mm. (*5 1/8″*)	...	$\frac{H}{d} = \frac{1}{K}$, where d = length. $\frac{1}{K} = \frac{1}{300}$ with V = 40 km. (*25 m.p.h.*) $= \frac{1}{400}$ with V = 40 to 55 km. (*25 to 34.2 m.p.h.*) $= \frac{1}{500}$ with V = 60 to 65 km. (*37.3 to 40.4 m.p.h.*) $= \frac{1}{600}$ with V = 70 to 80 km. (*43.5 to 50 m.p.h.*) $= \frac{1}{700}$ with V = 85 to 90 km. (*52.8 to 56 m.p.h.*)
3	*Danish State Rys.*	$3.9 \times \sqrt{R}$	$4.5 \times \sqrt{R}$	$8 \times \frac{V^2}{R}$	150 mm. (*6″*)	$\frac{11.8 \times V^2}{R} - 90$	1 : 10 $V_{max.}$
4	*Hungarian State Rys.*	(*) see hereunder.	5-10 km. *(3.1 to 6.2 miles)*	...	100 to 110 mm. (*4″ to 4 3/8″*)	...	1 : 10 × $V_{max.}$

(*) Permissible speed V on the Hungarian State Rys.

R		V max.	
metres.	chains.	km./h.	m.p.h.
1 300	65	120	74.6
1 200	60	115	71.5
1 100	55	110	68.4
1 000	50	105	65.3
900	45	100	62.1
800	40	95	59.0
700	35	90	56.0
600	30	85	52.8
500	25	80	49.7
400	20	75	46.6
350	17 1/2	70	43.5
300	15	65	40.4
275	13 3/4	60	37.3
250	12 1/2	55	34.2
200	10	50	31.1
180	9	45	28.0
150	7 1/2	40	24.9
120	6	40	24.9
100	5	25	15.5

(*) Permissible speed V on the Swiss Federal Rys.

R		Fast diesel railcars and electric motor coaches.		Light express trains.		Ordinary trains.	
metres.	chains.	km./h.	m.p.h.	km./h.	m.p.h.	km./h.	m.p.h.
245	12 1/4	75	46.6	70	43.5	65	40.4
280	14	80	49.7	75	46.6	70	43.5
320	16	85	52.8	80	49.7	75	46.6
360	18	90	56.0	85	52.8	80	49.7
410	20 1/2	95	59.0	90	56.0	85	52.8
465	23 1/4	100	62.1	95	59.0	90	56.0
520	26	105	65.3	100	62.1	95	59.0
580	29	110	68.4	105	65.3	100	62.1
650	32 1/2	115	71.5	110	68.4		
730	36 1/2	120	74.6				
830	41 1/2	125	77.7				
940	47	130	80.8				
1 050	52 1/2	135	83.9				
1 170	58 1/2	140	87.0				
1 290	64 1/2	145	90.1				
1 420	71	150	93.2				

(*) The gradient is 1 : 400.
With R = 600 m. (30 chains) and H = 117 mm. (4 19/32"), length d must be 70 m. (230'), thus inclination = 1 : 600.

only while trains whose speed exceeds 120 km. (75 miles) an hour are passing.

The Danish State Rys. have enforced more stringent regulations for the closing of level crossing gates since the speeds were increased. They are doing everything possible te replace such level crossings by bridges.

The Hungarian State Rys. have equipped a certain proportion of formerly unguarded level crossings with gates. They consider that the increase in the cost of crossing keepers varies from 4 to 10 % on the different lines in question.

The Swiss Federal Rys. replied that they have taken no steps to further protect their level crossings as a result of introducing higher speeds.

The Railways consulted are unanimous in stating that the increase in the speed has not necessitated any new types of permanent way. The Danish State Rys. propose to use new 60 kgr./m. (121 lb. p. yd.) rails in the future.

The Swiss Federal Rys. weld shorter rails into lengths of 36 m. (118 ft.). In addition they have introduced larger bearing plates for wood sleepers, secured by three coachscrews. The Bulgarian State Rys. and the Swiss Federal Rys. are progressively strengthening their track by increasing the sleepering.

As on lines including many curves the average speed depends to a very great extent on the speed allowed through these curves, certain Railways, amongst others the Deutsche Reichsbahn, revised the regulations or laid down new rules when the passenger trains were speeded up. The formulæ applied by the various Railways for the speed allowable through curves, for the superelevation of the outer rail and the superelevation gradients are shown in Table 10.

All the Railways who replied to this question allow their railcars to run through curves at 5 to 10 % higher speeds than trains hauled by locomo-

tives. The Swiss Federal Rys. intend to revise in the near future all the regulations about superelevations and superelevation gradients.

An investigation into the question of the influence of speeding up the trains on the construction and maintenance of bridges, has led the Deutsche Reichsbahn to the decision that an increase in the speed as a rule only affects bridges located on curves, i.e. on sections of the line where the speed is already reduced for other reasons. It is hardly ever necessary to strengthen bridges owing to the increased speed. The cost of so doing, which varies considerably, according to the number of bridges on curves, is on the average very low.

In carrying out the electrification of their lines, the Swiss Federal Rys. often found it necessary to strengthen bridges on account of the increased axle loads. The higher speeds have had no ill effects on bridges improved in this way, so that the maintenance costs have not increased with the speeding up of the trains. It is considered, however, that it is advisable to avoid joints by welding the rails together, both on metal and masonry bridges.

In the same way, the Bulgarian State Rys. have strengthened some of their bridges not on account of the speeding up of the trains, but because of the increased axle loads of the locomotives.

The Danish State Rys. have investigated the lateral stresses due to higher speeds. In certain cases they afterwards found it necessary to strengthen the cross stays absorbing the transverse stresses. But the cost of doing this is so low that there can be no question of a general increase in the maintenance costs of bridges.

On the Hungarian, Norwegian and Swedish State Rys., the speeding up of the trains has not made it necessary to strengthen any of the bridges nor given rise to increased maintenance costs.

7. Improving signals and brakes.

The speeding up of express trains has led the Deutsche Reichsbahn, the Danish and Hungarian State Rys. and the Swiss Federal Rys. to increase the distance between the home signals and corresponding distant signals on lines run over by particularly fast trains, proportionally to the increase in braking distances. This distance between signals has been increased from 700 to 1 000 m. (2 300 to 3 300 ft.) on the Reichsbahn, from 400 to 800 m. (1 300 to 2 600 ft.) on the Danish State Rys., and to 1 000 m. (3 300 ft.) on the Hungarian State Rys. On the Swiss Federal Rys., some of the distant signals have been moved back more than 200 m. (650 ft.). The Bulgarian State Rys. also propose to increase the distance between such signals in the future.

In addition the very great speeds of the express trains has led some Railways to use three-aspect distant signals. The Reichsbahn has fitted its distant signals with an additional indication. In this way three indications are possible : « Stop », « Line clear » and « Proceed at reduced speed ».

The speed limit is generally fixed at 40 km./h. (25 m.p.h.). When the authorised speed is higher or lower than this, the Reichsbahn proposes to put a special sign between the distant signal and the home signal showing the speed allowed, and marking the beginning of the section on which such a speed must be observed.

The Danish State Rys. are able to give three indications with their modified distant signals : « Stop », « Line clear for a train stopping at the next station », and « Train can run through next station without stopping ».

The cost involved in moving and altering signals is high, according to the information supplied by the Railways :

— On the Reichsbahn, 2 000 Rm. per km. (3 200 Rm. per mile) of single track;

— On the Hungarian State Rys., 200 P.

per km. (320 P. per mile) of single track;

— On the Swiss Federal Rys., 380 fr. per km. (610 fr. per mile) of single track;

— On the Danish State Rys., 13 000 Kr. per station.

The Deutsche Reichsbahn, the Hungarian State Rys., and in certain instances the Bulgarian State Rys., use fixed signs to mark the distant signals, whereas the Danish, Norwegian and Swedish State Rys., as well as the Swiss Federal Rys., do not give any advance warning of distant signals.

The visibility of the home signals has been improved on the German Reichsbahn by using higher posts, enamelled signal arms and boards, and glass reflectors on the signal lamps.

The Swiss Federal Rys. put up 80 × 80 cm. (2' 7 1/2" × 2' 7 1/2") speed boards with oblique black and white stripes, in the case of permanent speed restrictions on the running line (curves, etc.) at the beginning of the sections concerned. A sign of the same size gives warning of the main sign together with the authorised speed 300 m. (about 1 000 ft.) behind it. At the end of the reduced-speed section, there is a speed de-restriction board with vertical black and white stripes.

On all the Railways, the usual signal regulations also apply to the fast trains, as do the speed restriction signals covering permanent way repair work, etc.

When adopting higher speeds, the Reichsbahn perfected and installed automatic train control. The track equipment (electro-magnets connected by cable to the signals) cost on the average 750 Rm. per km. (1 200 Rm. per mile) of single track.

The Swiss Federal Rys. have adopted automatic train control (Signum system), not on account of the speeding up of passenger trains, but for general safety reasons, on all their electrified lines. The track equipment costs about 720 fr. per km. (1 160 fr. per mile) of single track (Swiss currency).

The Bulgarian, Danish, Hungarian, Norwegian and Swedish Rys., have not made use of any automatic train control equipment up to the present.

In order to be able to stop in the distance between the distant and home signals in spite of the higher speeds, certain railways have also improved the brakes on their rolling stock. On the German Reichsbahn the maximum speeds of 110 and 130 km./h. (68.3 and 81 m.p.h.) per hour with the respective distances of 700 and 1 000 m. (2 300 and 3 300 ft.) did not require any improvements or alterations to the brakes. The KKS brake used for many years on the corridor coaches suffices at these speeds for getting in every case a braking distance 10 % less than the distance between the signals. In the case of steam locomotives, the usual brakes could be retained, but the braking effort on all the wheels was improved, as far as possible with two blocks per wheel, and by improving the efficiency of the brake rigging.

With very high speeds, the distances between the signals being those quoted above, locomotives and coaches must be equipped with a very powerful and quick-acting brake (SS brake) by means of which the vehicles are braked with a brake block pressure of 200 to 220 % of the axle load. A centrifugal regulator worked by one of the axles reduces the pressure of the blocks to about 75 to 80 % of the load when the speed falls to 50 to 60 km./h. (31 to 37.3 m.p.h.). With such brakes, a train running at 150 km./h. (93 m.p.h.) can stop in about 900 m. (2 950 ft.).

The brakes used on electric locomotives suffice for stopping vehicles running at the maximum speed in a distance of 1 000 m. (3 300 ft.) after passing the distant signal. Locomotives of the 1Do1 type, class E18, are equipped with the HiKSS brake. The driving wheels are

braked to 180 % of the static axle load, the trailling carrying wheels with 150 % and the leading carrying wheels with 50 %. On the 1Do1, class E19 locomotive, the particularly high speed of 180 km./h. (112 m.p.h.) made it necessary to increase the braking power to 230 % for the driving wheels and 200 % for the trailing carrying wheels. In addition, this locomotive is equipped with a rheostatic brake, independent of the overhead line, which automatically comes into action when the quick-acting brake is applied and, in conjunction with the compressed air brake, assures the whole of the braking power coming into action simultaneously as far as possible, so that uniform retardation is obtained. In order to prevent the wheels being picked up at lower speeds, a centrifugal regulator cuts out the electric brake at 60 km./h. (37.3 m.p.h.), and reduces the power of the compressed air brake to approximately 80 %.

The Bulgarian State Rys. propose to use the compressed air brake instead of the vacuum brake to meet future requirements.

The passenger trains of the Danish State Rys. are still equipped with vacuum brakes, whereas the railcars and electric motor coaches have compressed air brakes. This Administration proposes to equip its passenger trains progressively with compressed air brakes.

The Hungarian State Rys. use the Knorr quick-acting brake with centrifugal regulator, for their streamlined locomotives.

The Swedish State Rys. are equipping all their new passenger stock with the HiKS brake and also intend to equip rolling stock of recent construction already in service with this brake.

The Swiss Federal Rys. have equipped their new light-metal coaches with an automatic compressed air brake, the power of which depends on the speed. At high speeds these brakes act with a block pressure equal to about 140 % of the axle load. The pressure of the blocks decreases automatically as soon as the speed has been reduced to 40 km./h. (25 m.p.h.) by the brakes.

So long as there are still not enough light-metal coaches in service and coaches of the ordinary type have to make up a certain number of light trains, the pressure in the main pipe of the automatic brake of these vehicles will be increased to 6 kgr./cm² (85 lb./sq. in.) in order to have sufficient braking power at high speeds.

III. — Operating by means of railcars.

1. General considerations.

The introduction of railcars was due first of all to economic reasons. This is why the use of railcars on a fair scale only started with the general crisis, though the beginnings of railcar construction go back to a much earlier date. The first railcars were equipped with engines like those used on motor lorries, in particular petrol engines of well-known makers, and had mechanical drives. On most railways, the nominal powers were just sufficient to enable them to run the vehicles to the timings and at the speeds then in use, and assure a sufficiently regular service. The small railway systems, or those carrying very little traffic, were contented with these vehicles, which moreover are still in use on many systems.

The next step was inspired by a desire to improve and speed up the service. To do this it was necessary to design completely novel types of motive power for railcars, since those used up to date could no longer meet the requirements of rail transport. It was above all the use of high-power diesel engines, with their greater advantage from the thermal point of view, which gave rise to considerable difficulties, especially as for reasons of weight and size it was very often necessary to use diesels revolving at a high speed. This

TABLE 11.

Progressive introduction of internal-combustion-engined railcars on the Deutsche Reichsbahn.

Distances covered, in thousands of train-km. *(in thousands of train-miles).*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Serial number.	Year.	Class of lines.	Express trains.			Semi-express trains			Local trains.			All passenger trains.		
			Together 1 000 km. *(1 000 miles).*	Railcar portion.		Together 1 000 km. *(1 000 miles).*	Railcar portion.		Together 1 000 km. *(1 000 miles).*	Railcar portion.		Together 1 000 km. *(1 000 miles).*	Railcar portion.	
				1 000 km. *(1 000 miles).*	%		1 000 km. *(1 000 miles).*	%		1 000 km. *(1 000 miles).*	%		1 000 km. *(1 000 miles).*	%
1	1934	Main lines . .	62 147 *38 617*	146 *91*	0.2	28 745 *17 862*	256 *159*	0.9	228 604 *142 050*	4 710 *2 927*	2.1	319 496 *198 529*	5 112 *3 177*	1.6
2		Branch lines . .	163 *101*	...	...	613 *381*	3 *2*	0.5	89 626 *55 692*	3 953 *2 456*	4.4	90 402 *56 174*	3 956 *2 458*	4.4
3		Standard-gauge lines.	62 310 *39 718*	146 *91*	0.2	29 358 *18 243*	259 *161*	0.8	318 230 *197 742*	8 663 *5 383*	2.7	409 898 *254 703*	9 068 *5 635*	2.2
4	1935	Main lines . .	67 295 *41 815*	632 *393*	0.9	32 859 *20 418*	1 363 *847*	4.1	250 141 *155 433*	8 389 *5 213*	3.3	350 295 *217 666*	10 384 *6 453*	2.9
5		Branch lines . .	178 *111*	...	...	702 *436*	11 *7*	1.5	96 707 *60 092*	6 156 *3 825*	6.4	97 587 *60 639*	6 167 *3 832*	6.3
6		Standard-gauge lines.	67 473 *41 926*	632 *393*	0.9	33 561 *20 854*	1 374 *854*	4.1	346 848 *215 525*	14 545 *9 038*	4.2	447 882 *278 305*	16 551 *10 285*	3.7
7	1936	Main lines . .	70 698 *44 552*	1 801 *1 119*	2.5	36 137 *22 455*	2 653 *1 648*	7.3	259 636 *161 333*	12 872 *7 999*	5.0	366 471 *227 720*	17 326 *10 766*	4.7
8		Branch lines . .	168 *105*	...	...	781 *485*	14 *9*	1.8	99 460 *61 803*	7 912 *4 916*	8.0	100 409 *62 393*	7 926 *4 925*	7.9
9		Standard-gauge lines.	70 886 *44 047*	1 801 *1 119*	2.5	36 918 *22 940*	2 667 *1 657*	7.2	359 046 *223 136*	20 784 *12 915*	5.8	466 880 *290 113*	25 252 *15 691*	5.4
10	1937	Main lines . .	75 759 *47 075*	2 281 *1 417*	3.0	39 430 *24 501*	3 554 *2 028*	9.0	267 449 *166 188*	15 684 *9 746*	5.8	382 638 *237 764*	21 519 *13 371*	5.6
11		Branch lines . .	178 *111*	...	...	847 *526*	26 *16*	3.1	102 652 *63 786*	8 872 *5 513*	8.6	103 677 *64 423*	8 898 *5 529*	8.6
12		Standard-gauge lines.	75 937 *47 186*	2 281 *1 417*	3.0	40 277 *25 027*	3 580 *2 044*	8.9	370 101 *229 974*	24 556 *15 259*	6.6	486 315 *302 187*	30 417 *18 900*	6.2
13	1938	Main lines . .	92 327 *57 370*	3 001 *1 865*	3.2	45 097 *28 022*	3 997 *2 484*	8.9	278 705 *173 182*	17 116 *10 636*	6.1	416 129 *258 574*	24 114 *14 984*	5.8
14		Branch lines . .	221 *137*	...	...	1 202 *747*	38 *23*	3.1	108 882 *67 657*	10 844 *6 738*	10.0	110 305 *68 541*	10 882 *6 762*	9.9
15		Standard-gauge lines.	92 548 *57 507*	3 001 *1 865*	3.2	46 299 *28 769*	4 035 *2 507*	8.7	387 587 *240 839*	27 960 *17 374*	7.2	526 434 *327 115*	34 996 *21 746*	6.6

second step in the construction of light railcars was the beginning of a development stage in which only a small number of important and financially powerful Railway Managements could share. In the space of a relatively few years, all the dynamic and thermic stresses to which all parts of the mechanical equipment of powerful railcars are subjected had been mastered, but at the cost of considerable expenditure and much patience. This evolution not only had the effect of introducing railcars into the field of high-speed traffic and main-line railway services, but also in its turn gave a considerable impulse to the speeding up of steam and electric trains.

Really methodical work to improve the railcar has been and could only be carried out by a small number of railways. Various Administrations obviously only put railcars into service for economic reasons, on secondary lines with declining traffic. Several Railways, taking advantage of the experience of other Administrations, subsequently introduced more powerful railcars, still for branch lines carrying little traffic, but only a few organised main-line or rather high-speed services, the engines still being of moderate power.

At the end of this period, the use of railcars is already an established fact, or will shortly, on some Systems; on others, it is still in a stage of evolution, but here also the construction of railcars is obviously getting out of the experimental stage as it has reached a point where experience may provisionally be considered as definite.

The economic value of the railcar, which will be discussed again at greater length, is not disputed by anyone.

The reliability of this vehicle, which thanks to the experience obtained in its construction is now practically a pure question of maintenance, ranks with that of other methods of traction, even in the case of very hard worked vehicles.

At the beginning railcars were always put into service either to give an additional service or to replace other train services. The Deutsche Reichsbahn introduced a complete railcar service on a few secondary lines served by local trains; a private Swedish Company proposes to do likewise as from May 1939. The high-speed railcars of the Danish State Rys. and of the Reichsbahn are run as new train services; under these conditions when railcars are not available, the Reichsbahn runs steam trains in their place, until such time as there will be a sufficient number of reserve railcars. To these steam trains the timetables allow extra time as a rule.

Railcars have been introduced on a wide scale in certain cases. In 1938, for example, the internal-combustion-engined railcars of the railways who replied to the question give the following proportions of the whole of the passenger train services :

Denmark,	41 %	approx.
Hungary,	22 %	»
Norway,	8 %	»
Germany,	7 %	»

Information about the development of internal-combustion-engined railcar services on the Reichsbahn since 1934 is given in Table 11. The total stock of railcars was :

172 in 1934,
316 in 1935,
383 in 1936,
440 in 1937, and
524 in 1938.

While the total train mileage increased by 28.5 % since 1934, there is an increase of 276 % in railcar mileage, the total stock of such vehicles having increased by 205 % since 1934. Consequently the average mileage of each railcar has increased by about 35 % since 1934.

The train frequency has been increased nearly everywhere with the introduction of railcar services, certain existing

train runs having been subdivided into several effected by railcars.

2. Operation and traffic.

Amongst other advantages the railcar makes possible an economical distribution of the traffic and an economical increase in the train frequency. It must, it is true, be made less sensitive to traffic fluctuations by making it possible to couple up several units together or adding trailers. The regularity of the service was insufficient in the first few years owing to the newness of this type of vehicles, especially those equipped with powerful engines, and through lack of experience.

As a result the policy of putting railcars into service was followed rather timidly at first. Technical improvements, however, and the growing popularity of these vehicles brought about a change confirmed by the reports received from many Companies.

On the Deutsche Reichsbahn, the daily mileages run are as follows :

1	2	3	4	5	6	7
Description.	Maximum.		Average.		Minimum.	
	Main lines.	Branch lines.	Main lines.	Branch lines.	Main lines.	Branch lines.
High-speed railcars . . { km. / *miles.*	1 300 / *810*	...	1 100 / *685*	...	1 050 / *650*	...
Other railcars . . . . { km. / *miles.*	800 / *500*	500 / *310*	600 / *375*	350 / *220*	400 / *250*	200 / *125*

These values generally agree with the mileage figures given by other Companies. According to the replies received, in addition to the Reichsbahn, there are only express railcar services and regular main-line railcar services on the Danish State Rys., the Swiss Federal Rys., the Hungarian State Rys., and a private Swedish Company. The high-speed railcars and a certain number of other railcars working on the main lines are run according to traffic requirements either singly as multiple-units, or as trains made up of two or several multiple-units. The Reichsbahn's railcars were put into service as supplementary services, to provide new connections, mainly with the object of assuring traffic to and from Berlin. On all the other systems, railcars are run either as a supplementary service, to increase the train frequency, or to replace steam trains.

Only in certain cases is there any reserve stock of railcars. As far as possible all the vehicles in working order are in service, and if none are available recourse is being had temporarily to other methods of traction. When there is a reserve stock, this is frequently a very high proportion of the total stock, as the total number of motor vehicles is relatively small. Percentage figures in this connection are therefore of limited value. In addition, reserve railcars are needed for economical working, as a reserve of steam trains reduces the economic value of the whole organisation to a very large extent.

The following approximate proportions of railcars available for service are obtained at present on the German Reichsbahn :

— In service, 60 to 70 % of all the railcars;

— In reserve and undergoing repairs, 30 to 40 %.

The proportion of railcars actually

undergoing repairs expressed in railcar — days is from 20 to 30 %. In particular it has not yet been found possible to reduce this number below 30 % in the case of high-speed railcars. It should however be noted that in the case of stock out of service for repairs, the time includes the total time required for alterations and improvements, which is rather long.

Much of the time required for maintenance work, such as inspection of the brakes and re-turning the tyres, depends in addition on the mileage run. This is why the high-speed railcars with their greater mileage require repairs at much shorter intervals than the ordinary railcars with lower maximum speeds and lower monthly mileages. This is a ready explanation of the high proportion of the stock undergoing repairs.

One particularly important question is that of meeting traffic peaks. By the addition of trailers or by coupling several railcars together, accompanied if need be by trailers, i.e. forming rail motor trains, the capacity can be adapted like that of other trains to variations in the traffic. There is, however, a limit above which the traction costs of such trains become higher than those for steam or electric trains. In addition, the formation of such sets is conditioned by the stock available, which in many cases is still insufficient. When there is not a sufficient number of railcars, at periods of heavy traffic, the Reichsbahn concentrates the railcars from the various lines on a smaller number of lines and replaces them on the other lines by steam trains.

Railcars are not used for trains *regularly* so well patronized that railcar sets would not be sufficient or would cease to be economical. In addition, the rule is that railcars are never used for express trains which include through coaches. The Reichsbahn's high-speed railcars only work day services.

A very important question is that of luggage and parcels transport, which generally causes special difficulties on secondary lines, i.e. the favourite field of the railcars. On main lines, the parcels traffic can as a rule be covered by the other trains (steam or electric), but on secondary lines, the parcels traffic offered is often very irregular and consequently gives rise to difficulties. A general solution of this problem is not possible, seeing that local conditions are often very different, even on the same railway. A rational solution to this problem in each particular case is of the greatest importance for the extension of railcar services.

In the case of rail motor trains, various Companies remind passengers that only a limited amount of luggage can be carried, but experience proves that most passengers do not bother about this restriction. The luggage compartment of the motor unit is, however, generally large enough to take all the luggage properly speaking. In case of special need, the vestibules in the other vehicles, and even on some railways the engine room, are used for this purpose. As an experiment the Reichsbahn has converted some old light passenger coaches to make them suitable for carrying small livestock or fish. On these coaches there is a luggage compartment completely separated from the passenger compartment, and therefore very suitable for railcar services. In place of a trailer of this sort a wagon can be added on occasion for parcels or other small consignments. Some Companies have special trailers for luggage.

The Reichsbahn also has a certain number of goods motor vans and is investigating their possibilities for future use.

In addition to the high-speed railcars which as a rule are only run as single units or at the most in pairs, other railcars haul special trailers which, on the Reichsbahn and certain other systems, are sometimes equipped with a driver's cabin. Some other Companies attach

ordinary stock to their railcars; very few Systems forego using trailers, and these are usually cases where vehicles of the omnibus type are used.

In many cases the trailers are of lighter construction than the ordinary passenger coaches. The railcars are generally sufficiently powerful to haul trailers without reducing the speed in any way. Only in the case of very exact timings and also on hilly lines is the journey time increased when trailers are coupled to the railcars, owing to the reduced accelerating power at starting. In such cases however the maximum speeds are not reduced at all, or not appreciably, unless braking questions come into the matter.

On the Reichsbahn, according to the gradients of the lines, each railcar can haul up to two trailers. Sometimes two of these sets of three units are coupled together. Some Companies add up to three trailers; it is true that in this case the available power sometimes decreases to 2 to 3 h.p. per ton. On the Reichsbahn all eight-wheeled trailers are fitted with a driver's cabin. Trailers with no driving gear are only coupled up to small railcars on secondary lines.

The number of men required to work such railcars varies according as the motor unit and the trailer are equipped for multiple control or not. In the future all the main-line railcars will be so equipped. Such a rail motor train will only need one driver.

If there are more than two power units in the train, the third will have to be occupied by a driver. Rail motor trains not equipped for multiple control require a driver for each power unit, the drivers of the different units being able to work together by audible signals (bells).

On the German high-speed railcars, the driver of the first unit always has a second man with him for safety reasons. This step is further justified by the long non-stop runs worked by these cars. If a second high-speed railcar is coupled up with the first and equipped for distant control, there is a driver on this car. The latter organisation is also resorted to on the Danish State Rys.

According to the information received from the various Companies, the driver of a railcar also acts as ticket inspector when the traffic is light.

3. Construction.

The existing types of railcars on the various systems vary largely according to the development stages through which they have gone, i.e. the more trials and experiments have been carried out, the greater the number of different types. The different types have already been listed in detail in the report on Question IV at the Paris 1937 Session of the International Railway Congress Association (English edition of this *Bulletin*, page 1281, May 1937). Most of the replies received indicate that the types of vehicles recently constructed are now to be taken as final types, as regards essentials. Sometimes they have already been called standard types. Standardisation on the basis of the experience obtained in practice, as is now in hand on the Reichsbahn, with possible alterations on a large scale of existing types, is out of the question on most Railways.

Inspired by the many designs put forward, the Reichsbahn has introduced standard types for new orders. In particular a standard programme has been got out for the control gear, according to which part of the existing stock will be altered, thereby making it possible for diesel-electric and diesel-hydraulic railcars to be coupled together and driven from a single driver's compartment. Standardisation of the vehicles from the constructional point of view is also in hand. A certain number of Companies propose to standardise their vehicles in the future.

As regards the principles of construc-

tion in general, the following points should be noted :

Weight per seat. — No numerical limits have been imposed on the weight per seat by the Reichsbahn. Lightened construction has made large weight savings possible. It is true that in recent types of high-speed vehicles, the measures taken to increase the comfort : spacious compartments, dining compartment, or buffet, etc., have increased the weight per seat considerably. This increase in weight will, however, be made good in the high-speed cars now being designed by extending the use of light construction.

For the other types of railcars on the Reichsbahn, and those of other Companies, the weight per seat of four-wheeled vehicles is about 300 to 400 kgr. (660 to 880 lb.), and that of the eight-wheeled cars 400 to 600 kgr. (880 to 1 320 lb.). Owing to the low power of the engines, on the private Halmstad-Nässjö Railway (Sweden) and the Swedish State Rys., the weight per seat had in certain cases to be reduced to 200 kgr. (440 lb.) before sufficient acceleration could be obtained. It is not possible to couple up units of this kind into rail motor trains.

Power/weight ratio. — According to the information received, the power per unit of weight varies between 5 and 20 H.P. per ton. This considerable difference proves that fundamental rules have not always been established in this connection, or else, as regards the lower figure, that sufficiently powerful engines are lacking in many places or that light construction has not been used. As regards the higher figure, this shows that an excessive importance has been attached to low weight. The figure of 19 H.P. per ton, for example, relates to a four-wheeled vehicle only weighing 6.7 tons with an engine developing 130 H.P. The highest powers are those of the rail omnibuses. The German Reichsbahn endeavours to obtain a power of 10 H.P. per ton but owing to increased comfort in the cars found it impossible to achieve this desideratum so far. The value of 10 H.P. per ton is necessary in view of the great importance of quick acceleration in increasing the average speed of passenger trains; it can be obtained with the present engine powers available on the eight-wheeled main-line railcars, which are more powerful and relatively more comfortable.

Number and arrangement of wheels. — The question as to the best wheel arrangement, as might be expected, has been answered in various ways. The advantages attributed to four-wheeled vehicles are their low weight, their lower cost, and the possibility of using them on secondary lines. Only a few Companies, amongst which the Reichsbahn, prefer bogie vehicles and eight-wheelers on account of their better riding. The Reichsbahn even wonders whether four-wheeled vehicles should not be completely abandoned in the future in spite of their recognised economic advantages. The Hungarian State Rys. also use six-wheeled vehicles on their secondary lines, the middle pair of wheels being given lateral play.

Types of engines preferred. — The diesel engine is preferred to the petrol engine. Opinions on the best kind of transmission are divided. The Swedish and Hungarian State Rys. prefer mechanical transmissions. The Danish State Rys. use electric transmissions exclusively. The latter is not liked on other railways, in particular those with steep gradients, on account of its high weight. The Deutsche Reichsbahn has used the three kinds of transmission successfully; at the present time, for powers over 225 H.P., electric and hydraulic drives are in the majority. Owing to the diversity of the traffic requirements and the particular properties of each kind

of drive, no definite opinion can be voiced. The Reichsbahn has taken the necessary steps to enable diesel-electric railcars and diesel-hydraulic railcars to be coupled together and driven by one man. The application of the same system to mechanical transmissions is now under examination.

Maximum speed. — This varies in the case of railcars for secondary lines between 60 and 90 km./h. (37.3 and 56 m.p.h.), and between 90 and 125 km./h. (56 to 77.7 m.p.h.) for main-line cars. The high-speed railcars of the Deutsche Reichsbahn have a maximum speed of 160 km./h. (100 m.p.h.). To make sure of faster acceleration on starting, the Reichsbahn has been content so far with a maximum speed of 90 km./h. (56 m.p.h.) for railcars used for short-distance services on main lines, but an increase in the speed limits for these vehicles is under consideration.

Comfort. — The Reichsbahn attaches particular importance to this question. The compartments are very spacious. On the high-speed railcars, there will be nothing but separate compartments in the future. In the same way, to allow passengers to move about freely, the corridors and vestibules have been given ample dimensions. The floors have been lowered as much as possible. The replies received from other Companies show that they also are attaching a growing importance to the question of comfort.

The comfort of the journey is closely bound up with :

— Smooth running. — All Railways with an extensive main-line system attach the greatest importance to damping out as completely as possible all shocks, vibrations, and noises in their railcars. For this reason, on the Reichsbahn the distance between bogie centres is made as long as possible, and the overhang reduced as much as possible. Care is taken to distribute the dead weight as evenly as possible. When using engines of high power, the mechanical equipment is mounted in the bogie or is supported thereby. The transmission of oscillations from the machinery is prevented by the use of springs so designed that their periods of vibration cannot synchronize and by fittings, of rubber for example, to absorb oscillations, as well as all sorts of shock absorbers, amongst which hydraulic shock absorbers carried by the body must be mentioned. Finally, the floors are often laid on a layer of insulating material. Tests made to obtain as smooth running as possible are still being carried out. In investigating this question, light construction will still raise a great many problems. The necessity of having a certain proportion between the weight of the engines and that of the body also appears of importance. Whereas the Swiss Federal Rys. think that when the weight is lower, the noise also decreases, other Companies point out that after a certain limit of weight reduction has been reached, it is no longer possible to damp out vibrations efficiently.

— Mechanical equipment. — The Deutsche Reichsbahn considers that it is of particular importance to have all the running gear requiring periodical maintenance easily accessible, in order to shorten the maintenance times. Special importance is also attached to diminish liability to freezing, by heating the cooling water circuit through an outside source of heat, and to the protection of the high-speed high-power engines against damage due to heavy permanent loads by cooling the engine lubricating oil, and the oil for the hydraulic transmissions. Most Companies are content to meet the risk of congelation by adding some anti-freezing compound. The Danish State Rys. have provided for the automatic emptying of the cooling water circuit into

heated reservoirs. The engine is generally given a double casing, especially when it projects into the body of the vehicle, in order to damp out noise.

Streamlining. — In view of the importance of air resistance at high speeds, some Railways have followed the example of the Reichsbahn and streamlined their railcars. If need be, the trailers are designed in the same way.

3. Maintenance.

The maintenance requirements of railcars varies very widely. The total maintenance time depends in the first place on the work to be done on the engine and its accessories. The time required depends very largely on the training and experience of the staff, as well as the fatigue the cars undergo in service. Often on one and the same railway, it varies considerably from one maintenance shop to another. If it is true that with good current maintenance the working reliability and the economic value of the vehicle can be considerably improved, it is also probable that some depots spend too much time on such work. It is permissible to foresee that in time greater practical skill, greater experience and the technical improvements made to the vehicles will reduce the maintenance times and bring them all down to a certain standard.

Not every Railway makes a local and administrative distinction between running maintenance shops and repair shops. This also contributes to the wide differences in the amount of maintenance work and the time spent on same, and the reason why many Companies did not wish to express any opinion on the subject is doubtless to be found therein.

A mileage basis for general overhauls has been adopted almost everywhere, though it is true that it varies considerably. In nearly all cases railcars are maintained in given central shops. If these do not lie on their usual route, they are sent thereto light. Owing to the general increase in the extent of motorisation, many places are already able to maintain railcars of the simpler types or carry out simple maintenance work on important classes of railcars.

The railcars are protected against the weather by being garaged in sheds. At first old locomotive sheds were generally used. Up to the present only in very rare cases have new sheds been built specially for railcars.

Care has been taken everywhere to heat the sheds adequately.

Refuelling plant is found at nearly all the railcar sheds. The larger stores are equipped with several tanks so that the fuel is stored for a longer period and any impurities are deposited on the bottom.

In large centres, specially equipped shops have been erected with stores of spares. Special equipment is sometimes included, for example that required for the loading and maintenance of accumulators and for the maintenance of brake equipment.

Replies to the question as to the life of railcars show a great diversity. It is to be expected that the life of the machinery will be appreciably shorter than that of the vehicle itself, unless periodical general overhauls make it possible to fully recondition the engines. Owing to the time required for engine repairs, spare engines are generally kept in reserve, so that each railcar gets a new engine from time to time. This is why it is necessary to make a distinction between the life of the engine and that of the vehicle, as many Companies have done. From the replies received it appears that the life of the vehicle itself varies between 20 and 33 years. The Reichsbahn puts it at 25 years.

It is much harder to estimate the life of the machinery. Some Companies express it in engine-miles, others in years. The mileages quoted vary much, i.e. between 400 000 and 2 000 000 km. (250 000 and 1 250 000 miles). The Reichsbahn

considers that the transmissions may have as long a life as the vehicle. The engine can be made as new when undergoing general repairs. A mileage of approximately 200 000 km. (125 000 miles) between two heavy repairs is aimed at. In addition, an investigation is being made to see whether by fixing a maximum number of revolutions of the engine, the resulting mileage would reflect more accurately the real wear of the engine.

IV. — Economic effects of passenger train acceleration and financial balance sheet of operation by means of railcars.

1. — Capital cost of train acceleration.

The capital expenditure on train acceleration varies considerably from one Company to another.

Whereas the Bulgarian, Norwegian and Swedish State Rys. declare that they have incurred no capital expenditure in speeding up their trains, the Danish and Hungarian State Rys., as well as the Swiss Federal Rys., claim to have incurred some such expenditure on such work as improvement of the permanent way, relocation and improvement of the distant signals, or laying in large-radius turnouts.

In the last ten years the Deutsche Reichsbahn spent on such work :

(a) on improving the lines on 20 000 km. (12 500 miles) of single track (including the stations in the sections concerned, 2 000 Rm./km. (3 200 Rm. p. m.) = 44 million Rm.

(b) on 3 000 turnouts of 500-m. (25 chains) and 1 200-m. (60 chains) radius, 8 000 Rm. per turnout = ... 24 million Rm.

(c) on altering the location of outer signals and improving them, on 12 500 km. 7 460 miles) of single track, 2 000 Rm./km. (3 200 Rm. per mile) = . . 25 million Rm.

(d) on automatic train control equipment on 11 000 km. (6 835 miles) of single track and 480 railcars, 1 180 Rm./km. (1 800 Rm. per mile) = 13 milion Rm.

Total. . . 106 million Rm.

The total capital expenditure in the last ten years for speeding up the trains on the Reichsbahn is consequently 106 000 000 Rm.

2. Current expenses varying as the speed.

A large part of the total costs for passenger train operation is quite independent of the speed, for example all the expenses in connection with such items as dealing with passengers at stations, making up the trains, the various operations required to receive and despatch the trains, and with a few exceptions, permanent way inspection. The other expenses in connection with a train service vary more or less with the speed; these can be divided into two groups. The first group includes the expenses directly or indirectly incurred for hauling the trains, and consequently represent a consumption or wear which increases as the speed becomes higher. The locomotive maintenance, fuel, lubricants, etc., and the maintenance and renewal of the track come in this group. The second group includes expenses which must be taken as fixed annual charges. As the faster trains can work a greater mileage with the same expenses, they are spread over a greater number of miles as the speed increases, so that each train-mile costs less. In this group come the expenses in connection with the travelling staff (driver, guard, ticket inspector), the cleaning and maintenance of the vehicles, as well as their renewal and interest on the capital they represent.

In recent years, the Reichsbahn has closely investigated the question as to what extent the cost of a train run depends on its speed. The result of this

Explanation of German terms in graph (Table 12 :

Mittl. Fahrgeschw. = average running speed. — Unterhaltung des Oberbaus = permanent way maintenance. — Erneuerung des Oberbaus = permanent way renewal. — Betriebsstoffe = materials. — Lok. Betriebspflege (Unterhaltung) = locomotive operation (maintenance). —Lok. Erneuerung (Verzinsung) = locomotive renewal (amortization). — Wagen Betriebspflege (Unterhaltung) = coach operation (maintenance). — Wagen Erneuerung (Verzinsung) = coach renewal (amortization). — Personal = staff. — Zugbegleiter = guard. — Lokführer = locomotive driver.

enquiry is given graphically in Table 12. The figures relate to average trains shown in the statistics, and given in the lower part of the table. The laws according to which the different factors of traction costs increase or diminish as the speed are clearly shown. The vertical downward arrows show the real average speed of present-day passenger trains. As can be seen, the economic speed limit has not yet been reached by any category of train.

3. Financial results of the speeding up of passenger trains as a whole.

If the average trains given in the statistics (Table 12) are compared with the whole of the passenger trains, it will be seen that the increase in the speed from 45 to over 49 km./h. (28 to over 30.5 m.p.h.) which took place between 1932 and 1938, lowered the costs by 3.2 %. If the Reichsbahn trains were still running at the same speeds as in 1932, about 27 million Rm. more would have had to be spent on the passenger train services in 1938. This is such a large sum that even after deducting the interest and amortization charges on the capital expenditure given in Chapter IV, paragraph 1, there is still a considerable saving. The Reichsbahn believes that this proves the economic value of speeding up the passenger trains as far as cost is concerned. As regards the receipts, it is impossible to give any information, even approximate, as it is not possible to estimate how much of the large increase in traffic is due to the general trade recovery and how much to the speeding up of the service.

4. Financial balance sheet of operation by means of railcars.

The replies to the question of the economic value of railcar operating were generally in its favour. Accurate information is however lacking, owing to the fact that the Companies themselves still do not know the exact results, or else because the stock in service is still too small.

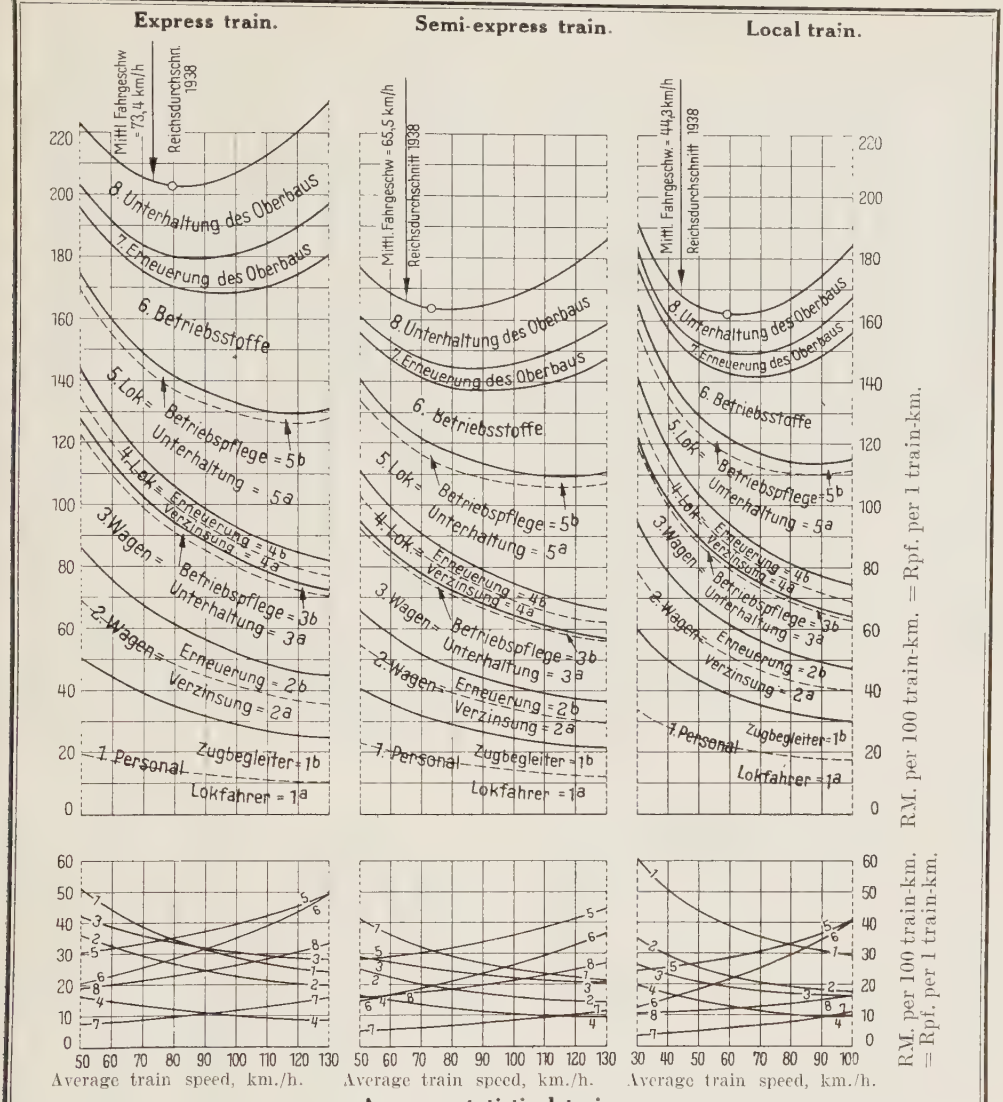
The information supplied in the reports and that collected by the Reichsbahn, makes it possible to say that, generally speaking :

The cost of railcars, in comparison with the aggregate train mileage, according to the figures given by the different Companies, works out at about 15 to 30 % of the total costs. On some Systems, thanks to the fact that they are worked by a single man, they are only 1/3rd the costs for steam trains. Apparently railcar drivers, owing to their professional training and position rank after locomotive drivers. As a rule, therefore, the staff costs are only 50 to 60 % of those for engine drivers, a source of considerable savings. The cost of materials varies between 10 and 25 % of the total costs; the amount depends essentially on the market prices, and could hardly be cut down.

The maintenance costs are generally 30 to 40 % of the total costs; in certain cases they are as much as 50 % and even more. One of the reasons is that, as stated above, no fast rules are regards repairs and current maintenance have been laid down so far. It is extremely important to find the exact limits and shorten as much as possible the time required for maintenance by rational organisation, well trained staff, and the in-

TABLE 12.

Costs — dependent on the train speed — of a run effected at different train speeds.


Express train.
Semi-express train.
Local train.
Mittl. Fahrgeschw. = 73,4 km/h
Reichsdurchschn. 1938
Mittl. Fahrgeschw. = 65,5 km/h
Reichsdurchschnitt 1938
Mittl. Fahrgeschw. = 44,3 km/h
Reichsdurchschnitt 1938
8. Unterhaltung des Oberbaus
7. Erneuerung des Oberbaus
6. Betriebsstoffe
5. Lok = Betriebspflege = 5b
Unterhaltung = 5a
4. Lok = Erneuerung = 4b
Verzinsung = 4a
3. Wagen = Betriebspflege = 3b
Unterhaltung = 3a
2. Wagen = Erneuerung = 2b
Verzinsung = 2a
1. Personal
Zugbegleiter = 1b
Lokfahrer = 1a
RM. per 100 train-km. = Rpf. per 1 train-km.
Average train speed, km./h.
Average train speed, km./h.
Average train speed, km./h.
RM. per 100 train-km. = Rpf. per 1 train-km.

Average statistical trains.

—	Train weight (incl. loco.) Metric t. (*Engl. tons*).	Staff.	Intermediate stops per 100 km. (*per 100 miles*)	Minutes per stop.	Average hourly running speed km. (*miles*).	Distance covered yearly by locomotives, km. (*miles*).	Distance covered yearly by coaches, km. (*miles*).
Express train .	526 (*517.6*)	2-Locom. 2-Train.	2 (*3.2*)	5	73 (*45.4*)	100 000 (*62 100*)	75 000 (*46 600*)
Semi-express train.	348 (*342.5*)	2-Locom. 2.52-Train.	3 (*4.8*)	5	62.3 (*38.7*)	80 000 (*49 700*)	70 000 (*43 500*)
Local train . .	253 (*249.0*)	2-Locom. 2.12-Train.	19 (*30.6*)	1.6	43 (*26.7*)	50 000 (*31 050*)	34 000 (*21 100*)

troduction of suitable auxiliary equipment. It is probable that once standard types have been adopted, it will become much more simple to do this.

Interest and amortization represent about 10 to 15 % of the costs. In this connection, mass production only plays a relatively small part, seeing that on most of the railways the requirements are not large enough to obtain appreciable savings from this method.

A complete financial balance sheet of railcar operation can not yet be drawn up, seeing that no Company has kept separate accounts for its railcar services. It is possible, however, to get a very good idea of the general results.

First of all some idea can be got by comparing the ratio of the total traction costs with the railcars to the annual mileage of the railcars in question. It is true, as several Companies point out, that this value does not represent the exact total cost of the average car-mile, since certain important factors are left out, such as the track, buildings, and mechanical maintenance equipment. In the same way, the ratio of the total cost per mile to the average receipts per passenger mile does not give an absolutely undisputable figure for the minimum number of passengers required to justify the introduction of a railcar service, seeing that the receipts from luggage and parcels are not taken into account. All the same these two figures give a basis for approximate calculations.

For existing conditions on the Reichsbahn, the following maximum number of seats justifying the introduction of railcar services have been determined :

Four-wheeled railcars, about 100 seats (power unit plus trailer);

Eight-wheeled railcars, about 500 seats (two power units plus four trailers with multiple-control gear);

High-speed railcars, about 200 seats (two units coupled together).

These figures show the important part played by the railcar, especially on main lines.

Some idea of the numerical value of the saving made by putting railcars into service can be obtained by considering the ratio of the cost per mile of steam trains to that of reilcars. In unfavourable cases, this ratio is about 1 : 6, but in the greater number of cases, it may reach 2 or even 4. With a coefficient of 1 : 6, the traction costs properly speaking are reduced, by the introduction of a railcar service, by about $\frac{1.6-1 \times 100}{1.6}$ = 37.5 % per car-km. Given the mileage of the railcars and the costs of comparable trains, it is possible to calculate approximately what savings can be made.

All the Companies are unanimous in stating that it is impossible to give any details about the increased receipts due to the introduction of railcar services.

Consequently it is impossible to draw up any financial balance sheet for railcar operation.

V. — Programme for the future.

The Deutsche Reichsbahn does not intend to raise in the near future the *maximum* speeds now run on the main lines. It hopes to be able to improve still further the *average* speed of passenger trains, when more new lightweight coaches will be available. The number of lines having high-speed railcar services will be increased; at the same time steps will be taken to increase the capacity of the high-speed railcar trains in proportion to the growing traffic requirements. Finally it is proposed to extend the railcar services to more main lines.

On the secondary lines, the Reichsbahn continues its efforts to equip a greater number of lines in such a way that the maximum allowable speed can be increased to 60 km./h. (37 m.p.h.) and over. A further speeding up and

increase of passenger traffic on the secondary lines is being investigated, in particular by the multiplication of the railcar services with more powerful units. So that the railcars can be used over both the main and secondary lines more freely, future railcars will be equipped with standardised control gear and coachwork.

The difficulties railcar operating has caused on secondary lines in the case of goods transport will be overcome by putting into service special goods motor vans with a separate luggage compartment. When it is advisable, these units will also haul other vehicles, either passenger and/or goods vehicles.

The Bulgarian and Norwegian State Rys. also intend to multiply their railcar services. In particular the Norwegian State Rys. propose to introduce railcar services first of all on all the lines carrying little traffic, and then to supplement their principal express train services by new high-speed railcar services. They expect to complete this programme by the end of 1943.

The Hungarian State Rys. intend first of all to improve their lines, then to modernise their rolling stock, after which they will be able to deal successfully with the speeding up of their passenger services.

The Swiss Federal Rys. do not intend to purchase any new railcars for the time being, neither single nor multiple units; they prefer trains made up of light metal coaches which can be marshalled in different ways. To increase the speed of these trains, they are building light electric locomotives with a luggage compartment, and a maximum speed of 125 km./h. (77 m.p.h.). The light-metal coaches used on these trains, which ride very well, are to be improved and their number increased. In the case of secondary lines with steam operation diesel-electric locomotives, for a maximum speed of 110 km./h. (68.3 m.p.h.), are under construction.

[656. 2]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION.

INQUIRY INTO QUESTIONS OF GENERAL INTEREST.

(Decision taken by the Permanent Commission at its Meeting held on July 9th, 1938.)

QUESTION II.

How should the problems of simplifying the working be considered, in the future, in the interest both of the public and of the railways?

REPORT

(Continental Main-Line Railways, except Belgium)

by Mr. GOURSAT,

Directeur du Service Central du Mouvement, French National Railways Company.

At its Paris Session (1937), the International Railway Congress Association investigated « The economical operation of main-line railways' secondary lines » (Third Section — Question VII).

As stated at the beginning of the questionnaire sent to the Railways concerned, the Permanent Commission of the Association considered that, in view of the frequency with which railway budgets showed a deficit, it would be a good thing to keep the Companies informed as to the developments of this question, and in particular of the results obtained and new methods put into practice or suggested since the last Session of the Congress.

The Permanent Commission also considered that a study of the simplification of operating methods should not be limited to the secondary lines, but also cover important and average lines, which form the essential parts of main-line systems.

The present report, therefore, consists of two parts :

— the first, dealing with the simplification of the operating of important and average lines, which in the following pages will be called *main lines;*

— the second, merely completing the information already collected in 1937 on the subject of secondary lines; this part is therefore less important than the first part, as nothing has occurred in the last two years to modify the question to any great extent.

We wish to thank all the Companies who replied in a very complete and detailed way to the questionnaire we sent them in order to collect the necessary information.

* * *

General.

In some countries, the lines have been grouped into « main lines » and

« secondary lines » and been officially recognised as such by the Public Authorities. In other countries, there is no such classification « a priori » and the distinction between them depends in fact on the maximum speeds allowed as well as the amount of traffic carried.

When there is an official classification, it does not always correspond to different operating conditions.

In the following pages, we have used the expression *main lines* for the important and average lines on which, as a matter of principle, normal methods of operating are in use, and the expression *secondary lines* for those lines carrying little traffic, usually worked according to simpler methods.

We also wish to make it clear that in the present report only the question of *simplifying the operating methods* is dealt with, i.e. that we left aside such matters as questions relating to the maintenance of the track or the hauling of the trains, although here again important savings can be made by simplified methods or a better adaptation of the equipment to the actual requirements.

* * *

Part one.

Simplifying the operating of main lines.

Before dealing with the problem properly speaking of simplified working of main lines, we think it would be as well to give a little information about the organisation of the services on such lines.

The traffic — passenger and goods — on the main lines may be considered as consisting of two clearly defined parts :

— on the one hand, the traffic from one important station to another over relatively long distances;

— on the other hand, traffic to or from the intermediate stations (small stations, yards, etc.) at short distances from an important neighbouring station.

Most often these two traffics are of unequal volume, and it frequently happens that the intermediate stations only have a very light traffic hardly justifying the trains serving them and the station staff it is sometimes necessary to employ. In such cases this short-distance traffic is furthermore particularly affected by road competition.

One profitable simplification therefore appears to be to give up entirely or partly the rail services to these intermediate stations, and to transfer this traffic to the road which is better able to cover it in most cases.

In actual fact, most of the Companies consulted continue to serve all the stations on the main lines by rail. Only a few Railways work the passenger transport by road, or certain goods traffic, such as the parcels traffic in the case of small stations. On the other hand, the French Railways, even on their main lines, have gone in wholeheartedly for co-ordination between rail and road transport. Such co-ordination which is at present limited to the passenger services is known as partial co-ordination (in contrast with the total co-ordination of certain secondary lines); the traffic from centre to centre is still worked by rail, whereas the intermediate places are served wholly or partly by road, with total or partial cancellation of the corresponding local trains. On the French Railways, at the present time, more than 3 000 km. (1 860 miles) of the main lines are worked according to this plan.

The experiment tried in France is still too recent a one for the results to be expressed in figures; moreover, this is rather a question of general co-ordination of the different methods of transport, the investigation of which would certainly go beyond the scope of this report.

* * *

The simplification of the operating of main lines should deal essentially with the following points :

(a) the fixed plant : buildings and signalling plant;

(b) the station staff;

(c) the train staff (traction and operating).

* * *

Generally when through a decline in traffic, for example, the *buildings* have become too large for the services to be covered, there are hardly any savings that can be made in this field, unless it be a question of out-of-date buildings whose reconditioning can be given up, or of proposed extensions which can be abandoned.

In stations of average importance, certain Companies have found it a good plan to combine the plant used for the full wagon load traffic with that used for the small consignments or even for passenger traffic, when this only involves making certain inexpensive alterations. Such a step, whilst making things more convenient for the public, saves staff, as the staff is brought together in one place, and can thus be used in the best way to meet the varying requirements of the service.

* * *

As regards the *signalling plant,* it seems possible to make important simplifications, particularly in the case of block signal and point operating plant. Such plant includes two kinds of equipment, namely :

— block signal boxes, from which the signals intended to maintain sufficient intervals between successive trains are worked;

— point operating boxes, from which however the block signals are also worked as a rule.

The possible modification of such equipment on a given line obviously depends on the intensity of the traffic on the line, as well as the kind of traffic.

On lines with very heavy traffic, the capacity of the line must be large, which means having the block signal boxes close together; if on the other hand, as is usually the case, there are a great many passenger trains, some of them running at high speeds, the greatest possible safety precautions must be taken.

Though, with the exception of France and Italy, most of the Companies consulted do not use it, it appears that the *automatic block* is one of the best ways of meeting these two conditions at one and the same time. It is true that its initial cost is relatively high, but on the other hand it not only makes it possible to eliminate altogether the intermediate block signal boxes, but it also considerably lightens the duties of the signalmen. In particular, it facilitates the generalisation of temporary boxes, i. e. boxes which are only staffed during the period actually required to work the points.

As regards signal boxes from which points are also operated several Companies report a tendency towards concentrating the different boxes of a station into one single box, the first cost being usually made good by the savings resulting from the fewer signalmen required. There is also no doubt that such concentration facilitates the management of the service.

Here again, the automatic block equipment makes it possible to go very far in the matter of such concentration, and lends itself particularly well to long-distance point operation (working a distant main-line turnout from a neighbouring station, etc...).

Long-distance point operation is found particularly suitable in the case of the operation through a control station (dispatching) of the signals and points of a section of line which can be run

through in both directions (centralized traffic control). Amongst the Railways consulted, such an arrangement has only been used up to the present in France. Many applications of this method have however been made in America, either on single-track lines where the traffic has become too heavy to be worked by the usual methods, or on double-track lines which it is sometimes preferable to turn into two single-track lines, or even on double-track lines, one track of which it has thus been found possible to take up, enabling an important saving to be made in the maintenance costs.

Naturally the automatic block, centralized traffic control, operation of points from a long distance, etc., cannot be made the general practice (1) on main lines. In certain cases, particularly on lines of average importance, the manual block, or even the telephone block, is the most economical solution, whilst assuring sufficiently safe working. There seems to be some value, however, in recalling that there are a number of technical means of making important economies in the utilisation of such plant; for example on lines where the amount of traffic varies, either at different hours of the day (light night traffic), or at certain periods of the year (seasonal traffic), it shoud be possible to turn the block signal boxes into « temporary » boxes, so that they can be put out of service during periods when they are not required. In the same way, it should be made possible for certain station signal boxes (from which points are operated) not to be staffed all the time. It is desirable, therefore, that the solutions adopted as regards signalling plant allow of such saving to be made, and that this be taken into account when drawing up new schemes.

* * *

Expenditure on *staff* accounts for the largest portion of the operating costs, so that this is obviously the field in which to look for substantial savings.

In this connection we will deal in turn with the station staff, and then the train staff.

* * *

In a station on a line carrying heavy or average traffic, operated according to the usual methods, on the one hand the safety of the working, and on the other hand the service properly speaking of the station (passengers, goods, handling, accounts, etc...) must be assured.

In the case of an important station, these functions : signalling, and the station service, are usually entrusted to separate groups of employees.

In the small stations on the contrary, the same men can combine the whole of the duties.

1. *Signalling staff.*

The signalling staff is expensive, first of all because the men must be specially selected and trained, and above all because of the continuous character of their duties. Whereas the traffic is often intermittent, and in the case of goods, for example, limited to part of the day, safety on the other hand must, as a matter of principle, be assured continuously throughout the twenty-four hours.

It is of particular interest, therefore, to reduce the signalling staff to a minimum.

Equipping the lines with the automatic block, as we have seen above, makes it possible to do away with a great part

(1) We must point out, however, that taking into account the increased labour costs apparent in the last few years, which are due both to higher wages and shorter working hours, it has often been found advantageous to undertake work which led to reductions in the staff required, and made it possible to substitute a fixed interest and amortization charge for an ever increasing wages bill.

of such staff; in the same way, concentration of the signal boxes makes possible important savings in the number of men.

Apart from such cases, a minimum signalling staff must obviously be kept at important centres.

In small stations, it would appear to be possible to make appreciable savings in various ways :

— by cutting out the signalling at the station during certain periods when the traffic is less intense (this saving is only a real one if such periods coincide with the closing of the station to all traffic) ;

— by reducing to the minimum the duties of the staff as regards work in connection with the safety of the working, so that a single station employee is able to do all the work, for example.

On double-track lines at least, the duties of the station staff in this connection can certainly be practically suppressed, so long as the train circulation remains normal; for example on the French Rys., on certain suburban lines, even when the traffic is very heavy, the usual duties of the station staff are merely to issue and collect tickets, the actual train service being covered by the train staff. Only if anything goes wrong — which obviously means only on rare occasions — have the station staff anything to do with the train circulation.

2. *Staff performing actual station duties* (passengers, goods, handling, accounts, etc.).

In large or average stations, the staff required to cope with normal traffic can generally be calculated pretty accurately.

At large stations, however, there are always certain hours of the day and seasons of the year when the traffic is particularly heavy. The difficulty of meeting traffic peak periods, mostly unexpectedly, with a given staff, is one of the most serious the economical operation of a railway comes up against.

One good solution to this appears to be to limit the permanent staff to the minimum required for dealing with the normal traffic, and complete it during peak traffic periods by auxiliary staff — essentially temporary — and used for the easier duties, thereby leaving the regular staff free to carry out the rest of the work required at the moment.

Another way of proportioning the staff to traffic requirements consists in temporarily transferring staff from one Department to another (Operating, Permanent Way, Mechanical and Running).

On the other hand, experience shows that it is advantageous to let private contractors carry out certain work in important stations on a piece-work basis (cleaning, heavy handling, etc.).

It may finally be pointed out that one of the largest items in staff expenditure in large stations is in the shunting yards, where in particular the manual braking of wagons makes it necessary to employ large numbers of men all the time.

The rational equipment of such yards has been particularly developed in Germany and France, and the improvements made in shunting conditions (improved signal towers, sometimes completely automatic), the introduction of automatic braking devices (track brakes) makes it possible to reduce the number of men employed whilst increasing the output of the yard.

However, to be remunerative, these very costly installations can only be carried out in important yards.

It therefore appears rational, whenever this is possible, to transfer, by altering the train workings if need be, all or part of the shunting operations carried out in average sized stations to a few very large centres with modern equipment, where the maximum output can be obtained with the minimum staff.

* * *

In the case of small stations, it is usually difficult, in view of the small vo-

lume of traffic, to proportion the staff to the work to be done; it is, however, often possible to take advantage of simplified working methods generally used on secondary lines. For example, to reduce the number of men employed in the stations, the first trains in the morning or last trains at night, which are usually little patronized, can be dealt with entirely by the train staff, including issuing and collecting tickets; in the same way, the management of the station can be handed over to someone not permanently employed by the Railway (some tradesman near the station, for example) who will only have to be there at certain hours of the day, and therefore will not have to be paid a very large wage.

* * *

The travelling staff is the other labour item on which large savings can be made.

Such staff includes :

— the enginemen, responsible on the one hand for driving the engine, and firing it in the case of a steam locomotive, and on the other hand for keeping a lookout for signals;

— the train staff, who normally deal with the train service (passengers, parcels, etc.) and who also have to ensure the observance of certain regulations (communicating with the signalman if the train is stopped by a signal, protecting the rear of the train by hand signals in the case of stops on the open road, seeking aid in case of breakdowns, etc.).

As regards the *enginemen*, it is, of course, not necessary to have a fireman whenever the engine does not require firing (electric traction, internal-combustion-engined locomotives, railcars, etc.) or when such firing is so reduced that the driver can easily attend to it in addition to his usual duties. From the point of view of safety, however, at least on main lines (we will deal with secondary lines later on) it then becomes necessary to guard against the danger of the driver becoming suddenly incapacitated, either by fitting such apparatus as the « dead man's handle » or by making it possible for the train staff to reach the engine cab or driving compartment.

Actually a great many Companies have done this on a large scale.

In addition to the French Railways, we may mention the German, Swiss, Italian, Swedish, etc., Railways amongst the most definite replies we received in this connection.

As regards the *train staff*, here again it is possible in most cases to transfer the duties imposed by certain regulations to other employees, the enginemen for example.

In practice the essential duties of the train staff are :

— on the one hand, protecting the rear of the train if it has to stop on the open road;

— on the other hand, working the hand brakes if need be in the rear portion of the train, the braking of the train being taken as assured by the compressed air brake worked directly by the driver.

The other obligations laid down in the regulations, such as communicating with the signalman when a train has been stopped by a signal, seeking assistance in case of a breakdown, etc., can be covered without difficulty by the driver.

The question of protecting the rear of the train if it has to stop on the open road, obviously will not arise in the case of main-line trains where the perfection of the block sections has made it possible to dispense altogether with any intervention of the staff if the train has to stop. This is so, for example, with the automatic block in France, or with certain absolute blocks; in other cases it is possible to assure similar protection either by a train employee if there is one (inspector, guard, etc.), or if not, by the fireman.

As for looking after the brake in the rear portion of the train, this can be suppressed, except perhaps on certain very long goods trains; with the latter there is always a remote possibility of a coupling breaking in the rear portion of the train without the driver noticing it. Moreover, the protection of the train, if it has to stop on the open road, by an employee at the leading end, would lead to an appreciable delay in protecting it by hand signals, at least in cases where such protection is wanted immediately.

The presence of any train staff on the train can most often be considered as useless from the safety point of view, and is therefore only justified by the amount of train service work to be done. It then becomes better to use specialised train staff (inspectors, conductors, etc.) in contact with the pasengers. It is also possible to run trains without any train staff in the case of through trains on which nothing has to be done en route, or in the case of trains serving stations where the staff is sufficient to do the necessary work.

Many Companies share these ideas. Some of them have gone very far in having their trains worked by a single conductor, in addition to the railcar services, and on the lines of the French National Rys. Co., for example, nearly 70% of the trains are now run in this way with a single conductor.

Some Companies have gone even further. The Swedish Rys. for example state that all their through goods trains are run without a guard, the work being done entirely by the enginemen, two in number in such cases. In the same way the German State Railways allow short passenger and goods trains to be run without guards.

In connection with this investigation into the staffing of trains, it appears advisable to insist on the value of the simplification of the safety regulations imposed on the train staff.

In our opinion it is only when these obligations are very simple that it becomes reasonably possible to make general the practice of letting the driver do everything, in addition to his real duties of driving the train and keeping a lookout for the signals.

Here is a guiding principle on which to base the regulations that the supervisory staff should never overlook.

We would also like to recall the fact that valuable savings can be made in the *utilisation* of the train staff, in particular as regards the men whose duties do not follow a regular routine, who should therefore be kept in reserve for manning possible additional optional trains, etc., made necessary by service requirements. The best solution in the case of lines with traffic control (dispatching) is to leave the task of co-ordinating the proper utilisation of the train staff in the hands of a single man.

* * *

Part two.

Simplified operation of secondary lines.

As stated at the beginning of the present report, the economical operation of the main line system's secondary lines was dealt with in Question VII (Third Section) at the 1937 Session of the International Railway Congress Association.

From the information collected recently from the various Companies consulted, it seems that the « summaries » put forward in 1937 by the Special Reporter, Sr. Palmieri, and adopted at the Plenary Meeting of the 7th June, 1937, do not need any modification as a whole, though the experience since acquired makes it possible to be more definite about some of them.

In the first place, as regards the main-line Companies' operation of their secondary lines, it appears advisable to stress a very important psychological

fact — we mean the habitual way of thinking of such lines. The « secondary lines mentality » is difficult to build up on a main line railway where the main lines are always considered first in the case of the least important decisions and consequently all the more so in the general instructions, and unconsciously everything becomes based on their requirements; the junior staff and local employees are promoted from the secondary lines to the main lines and follow the same practice both in interpreting and carrying out urgent orders, unless formal instructions are issued.

For this reason some of the former French Companies, and after them the French National Railways Company, have handed over the operation of some of their secondary lines to Local Light Railway Companies.

In every case the « secondary lines » mentality is essential if the main-line railway system wishes to introduce on its secondary lines economical operating methods comparable with those of the companies who specialise in working such lines, and with this object in view it is certainly of value to make an effort to train and select the staff, if there is no separate staff for each kind of lines.

* * *

This second part of the report will follow the same plan as the first part dealing with the simplified operation of main lines, though in a more summary fashion, so that we will deal in turn with the fixed plant, the station staff, and the train staff, and in addition with the question of dispensing with level crossing keepers in the future, which is of great importance for secondary lines.

As regards the *simplification of signalling equipment,* it is certainly possible to do away with signals altogether, even in stations where trains regularly meet on single-track lines, being content to have simple marker boards, which are not illuminated at night; in the same way the points can be operated on the spot, without any interlocking.

Such measure have actually been taken by most of the Companies consulted.

* * *

The reduction of the *station staff* is bound up with the regulations adopted for the operation of the lines, as far as the staff co-operating to the working safety is concerned. In this connection the following different solutions can be envisaged :

(a) the signalling is covered by the station staff in the same way as on the main lines, it being understood that the boxes may be staffed only intermittently;

(b) the working safety is the direct concern of the train staff, who are themselves responsible for the operations in connection with train meetings, and who receive the necessary directions (changed meeting places, etc.) by telephone from the single man controlling the traffic on the line. The Italian Railways seem to have developed this method on a fair scale; they call it the « single controller » system.

(c) Finally, combined solutions can also be adopted; for example, certain stations can be staffed, but the service at the intermediate ones between these can be covered by the train staff under instructions from the stations at both ends of the unstaffed section. Such an arrangement is in force on the Swedish Railways, for example, as well as on certain lines of the Swiss Railways.

All these different methods certainly give satisfactory results. Whether they are adopted or not depends on the staff which has to be maintained in the different stations to meet commercial requirements.

We might also point out that the French National Rys. Co. in endeavouring to standardise the different simpli-

fied operating methods in force on the former French Companies, are tending towards solution *(a)* in the case of secondary lines carrying passenger traffic, and towards solution *(b)* on secondary lines normally closed to passenger traffic and still run over solely by goods trains.

As regards the *train staff,* the ideas put forward in Part One in the case of main lines, are *à fortiori* applicable to secondary lines. In addition, on the latter it would seem possible to make the conditions in force on main lines still easier. For example in the case of an engine driven by a single man (railcars, etc.) it does not appear necessary to provide any such apparatus as the « dead man's handle» or require the driver to be assisted by any other employee. In the same way, it would be quite logical to increase the cases under which a steam locomotive can be worked by a single driver, without a fireman; the great distance between stations and the absence of signals to look out for gives the driver more time for firing his engine than on a main line.

* * *

Unlike what happens on the main lines, the small volume of traffic on secondary lines and the relatively low speeds make it possible to do away altogether with keepers at many level crossings, without it becoming necessary to equip such crossings with light signal equipment to give warning of the approach of trains, etc. in place of the gates or barriers. At level crossings where poor visibility makes it impossible to do away with gates, it is possible, at least in certain cases, particularly on lines without any passenger trains, to impose a special speed limit on the trains, so as to be able to dispense with keepers. It should however be noted that in view of the low speeds usually authorised on secondary lines, on which the maintenance costs must be reduced to a minimum, a moderate policy must be adopted for the speed restrictions thus imposed on trains when passing level crossings whenever passenger trains are concerned. Such restrictions must not cause too great a decline in the average speed of such trains, as this would have a harmful effect on lines which suffer from road competition.

When keepers have to be retained at level crossings, however, it is possible to limit the hours at which they have to be present to those at which trains are passing, the gates remaining open and unprotected between whiles. Naturally the running of special trains is as a rule forbidden at times when the crossings are not protected, and special precautions are imposed when a special train, for example a relief locomotive, has to be run.

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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION.

INQUIRY INTO QUESTIONS OF GENERAL INTEREST.

(Decision taken by the Permanent Commission at its Meeting held on July 9th, 1938.)

QUESTION I.

Methods used to speed up passenger trains and the resulting expenditure.

In particular, operating by means of railcars and the financial results obtained by this method.

REPORT

(Belgium and Colony, France and Colonies, Greece, Italy, Luxemburg, Netherlands and Colonies, Portugal and Colonies, Rumania, Jugoslavia)

by L. DUMAS,

Directeur attaché à la Direction Générale, French National Railways Company.

FOREWORD.

Between 1934 and 1938, the years covered by our investigation, all the Railway Managements consulted have made great endeavours to improve the passenger services on both main and secondary lines.

Generally speaking it may be said that these efforts, continued in spite of the world economic crisis and in spite of financial difficulties, often very serious ones, were mainly inspired by road competition.

The technical progress made during the preceding years by the motor industry in improving the comfort, speed, capacity and cost price of private motorcars, or motor char-a-bancs gave the road transport industry at the beginning of the period in question a considerable advantage over the railway; it was becoming increasingly said that the latter would have to abandon the struggle.

The railways, however, have not given up. It is even likely that had they shown any tendency to do so, the Government would have intervened and reminded them of their social duties the importance of which made it imperative not to give way, the railways being alone capable of carrying out the bulk transport essential for so many different reasons.

The railway had recourse to technical means to obtain the greatest possible value from the undoubted advantages it had over its competitors, chiefly on account of the fact that it is the owner of an ideal road, a practically level road over which it is easy to get much higher average speeds than road transport can hope for.

Guided more or less by the policy of the Government, according to the different countries concerned, the railway has endeavoured to get the maximum

out of the most recent progress, and in its turn has obtained remarkable results; in a very short time it has been able to adapt its old and at times out-of-date stock for speeded up services; it has had recourse above all to the diesel engine for its railcars; it has electrified and even built entirely new lines.

In many cases the railway has succeeded in getting back its former clients. In addition, it has reawakened the interest of the public by its efforts to modernize its operating methods and by its traditional qualities of regularity and safety which are again highly appreciated after a period of infatuation with the road.

The object of the present report is to outline not only the technical means used to improve and speed up the passenger services, but also the financial results obtained and to draw therefrom certain conclusions for future guidance.

The report is based on the following plan :

CHAPTER I. — *General.*

(A) Importance of the stage covered between 1934 and 1938.

(B) Chief characteristics of the improvements.

CHAPTER II. — *Improvements made to the motive power and rolling stock and to the fixed plant.*

(A) Motive power and rolling stock (railcars excepted).

(B) Fixed plant and signals.

(C) Safety problems raised by high-speed traffic.

CHAPTER III. — *The special case of railcars.*

(A) Chief services covered by railcars.

(B) Meeting peak traffic with railcars.

(C) Maintenance and garaging of railcars. Periods out of service.

(D) Annual mileage and amortization charges for railcars.

(E) The railcars under construction.

CHAPTER IV. — *Results of the policy of improving the passenger services.*

(A) Development of the traffic as a result of improved services.

(B) Comparison of the cost per mile of trains and railcars. — Cost per seat available.

(C) Present policy of the various Railway Managements.

CHAPTER V. — *Summaries.*

* * *

CHAPTER I.

General.

(A) Importance of the stage covered between 1934 and 1938.

We asked the Railways to give the total daily mileage covered by their passenger trains timed at a commercial (overall) speed of more than 96 km. (60 miles) an hour between two consecutive stops and to give us the figures from 1934 to 1938.

In 1938, this aggregate distance reached 35 716 km. (22 193 miles) compared with 8 587 km. (5 336 miles) in 1934, the total distance covered daily by passenger trains being 1 427 048 km. (886 745 miles) in 1938.

The proportion is 25 % in 1938 compared with 6.6 % in 1934.

In 1938 this aggregate distance was divided up amongst steam, electric traction and railcars in the following proportions :

Railcars .	14 437 km.	(8 971 miles) ;
Steam traction . .	13 418 km.	(8 338 miles) ;
Electric traction .	7 861 km.	(4 884 miles) ;
Total.	35 716 km.	(22 193 miles).

The Railway Managements concerned are the following :

France . .	24 490 km.	(15 218 miles)
Holland . .	5 435 km.	(3 377 miles)
Italy . . .	3 492 km.	(2 170 miles)
Belgium. .	2 299 km.	(1 428 miles)
Total.	35 716 km.	(22 193 miles)

Table A shows the figures in detail for each Railway and each kind of traction.

blic have nevertheless been effected; sometimes the journey time has actually been halved.

In addition a great many secondary lines where formerly there were only local services have now new, speeded up services between large towns, between which there used not to be any through services; the improvement of the service is so great that some of these new transverse services are worked at an average speed exceeding 96 km. (60 miles) an

TABLE A.

Daily passenger train mileages at overall speeds exceeding 96 km. (60 miles) per hour.

ADMINISTRATION.	Year.	Total daily passenger train mileage.	Daily passenger train-mileage at over 96 km. (60 mil.) p.h.	% of total train mileage covered at 60 miles an hour.	Method of traction used for daily mileage covered at over 96 km. (60 miles) an hour.		
					Steam traction.	Electric traction.	Rail-cars.
FRANCE.		Km. *(Miles).*	Km. *(Miles).*		Km. *(Miles).*	Km. *(Miles).*	Km. *(Miles).*
National Rys. Co. .	1934	...	8 587 *(5 336)*	...	8 237 *(5 118)*	350 *(217)*	0
	1938	778 459 *(483 721)*	24 490 *(15 218)*	3.15 %	11 123 *(6 912)*	3 840 *(2 386)*	9 527 *(5 920)*
BELGIUM.	1934	139 900 *(86 931)*	0	...	0	0	0
National Rys. Co. .	1938	183 850 *(114 241)*	2 299 *(1 429)*	1.26 %	1 965 *(1 221)*	0	334 *(208)*
ITALY.	1934	...	0	...	0	0	0
	1938	345 017 *(214 483)*	3 492 *(2 170)*	1.02 %	330 *(205)*	1 036 *(644)*	2 126 *(1 321)*
NETHERLANDS.	1938	119 722 *(74 393)*	5 435 *(3 377)*	4.55 %	...	2 985 *(1 855)*	2 450 *(1 522)*

Table B gives the characteristics of a few typical services speeded up by the Companies during recent years.

The figures given therein show that these services have been speeded up chiefly on the main lines.

On the secondary lines the layout of which makes average speeds nearing 96 km. (60 miles) an hour impossible, accelerations much appreciated by the public have nevertheless been effected; sometimes the journey time has actually been halved.

hour, so that some examples of them are listed in Table B.

(B) Chief characteristics of the improvements.

The chief steps taken to speed up the passenger services are as follows :

(a) Substitution for the steam trains of railcars with internal-combustion en-

T.

Typical accele

	High-speed service.	Gradients.	Maximum hourly speed in km. *(in miles)* p. h.		Distanc in km *(in mile*
			Theoretical.	Practical.	
BELGIUM. *Nat. Rys. Co.*	Brussels—Charleroi	Up to 1 in 77.	120 *(75)*	110 *(68)*	56 *(3*
	Brussels—Mons	Up to 1 in 167.	120 *(75)*	120 *(75)*	60 *(3*
	Brussels—Namur	Up to 1 in 56.	120 *(75)*	120 *(75)*	62 *(3*
	Brussels—Antwerp.	Up to 1 in 200.	120 *(75)*	120 *(75)*	46 *(2*
	Brussels—Ostend	Up to 1 in 200.	140 *(87)*	140 *(87)*	115 *(7*
	Brussels—Charleroi	Up to 1 in 77.	120 *(75)*	120 *(75)*	56 *(3*
FRANCE. *National Rys. Co.*	Paris—Lyons.	1 in 200 to 1 in 125.	130 *(81)*	120 *(75)*	511 *(31*
	Paris—Marseilles	Do.	125 *(78)*	115 *(71.5)*	862 *(53.*
	Paris—Port Vendres	Up to 1 in 100.	120 *(75)*	80 *(50)*	953 *(59*
	Paris—Belfort	1 in 333 to 1 in 167.	120 *(75)*	105 *(65)*	443 *(27*
	Nancy—Paris.	1 in 333 to 1 in 125.	120 *(75)*	110 *(68)*	353 *(21*
	Metz—Strasbourg	1 in 333 to 1 in 143.	120 *(75)*	110 *(68)*	155 *(9*
	Paris—Bordeaux	Up to 1 in 125.	130 *(81)*	120 *(75)*	579 *(35*
	Paris—Irun	Up to 1 in 100.	130 *(81)*	120 *(75)*	814 *(50*
	Paris—Le Mans.	1 in 333 to 1 in 143.	130 *(81)*	105 *(65)*	211 *(13*
	Paris—Strasbourg	1 in 333 to 1 in 200.	140 *(87)*	120 *(75)*	503 *(31*
	Paris—Lille	1 in 333 to 1 in 167.	140 *(87)*	122 *(76)*	258 *(16*
	Paris—Havre.	Up to 1 in 125.	140 *(87)*	116 *(72)*	228 *(14*
	Strasbourg—Lyons.	1 in 333 to 1 in 67.	140 *(87)*	110 *(68)*	471 *(29*
HOLLAND.	Amsterdam W.P.—Arnhem.	...	120 *(75)*	91 *(56.5)*	93 *(5*
	Amsterdam C.S.—Rotterdam D.P.	...	100 *(62)*	73 *(45.5)*	86 *(5*
	Amsterdam C.S.—Groningen	...	120 *(75)*	89 *(55)*	215 *(1*
	Do.	...	100 *(62)*	74 *(46)*	215 *(1*
	Nijmegen—Tilburg.	...	90 *(56)*	58 *(36)*	66 *(4*
ITALY.	Milan—Rome—Naples	...	160 *(100)*	145 *(90)*	846 *(5*
	Milan—Rome.	...	160 *(100)*	145 *(90)*	632 *(3*
	Leghorn—Rome	...	130 *(81)*	110 *(68)*	316 *(1*
	Rome—Naples—Reggio C.	...	160 *(100)*	120 *(75)*	688 *(4*
	Turin—Leghorn	...	130 *(81)*	110 *(68)*	351 *(2*

s in 1938.

ourney ime. M.	Daily number of services.	Rolling stock used.	Train weight. Metric *(Engl.)* tons.	Method of traction.
— 42	12 d. — 12 up.	Metal coaches.	260 *(255.8)*	Steam.
— 38	1 d. — 1 up.	Do.	600 *(590.5)*	Steam.
— 44	1 d. — 1 up.	Do.	350 *(344.5)*	Steam.
- 29	20 d. — 20 up.	Electric motor coach sets.	270 *(265.7)*	Electric.
— 03	1 d. — 1 up.	Railcars.	-	Railcar.
— 41	—	Do.	-	Railcar.
— 50	1 d. — 1 up.	Streamline train.	200 *(196.8)*	Steam.
— 05	1 d. — 1 up.	Standard metal coaches.	340 *(334.6)*	Steam.
— 46	1 d. — 1 up.	Do.	460 *(452.7)*	Steam and electric.
— 50	1 down.	Do.	390 *(383.8)*	Steam.
— 04	1 down.	Do.	540 *(531.5)*	Steam.
— 29	1 d. — 1 up.	Pullman—Edelweiss Express.	292 *(287.4)*	Steam.
— 20	1 d. — 1 up.	Standard metal coaches.	600 *(590.5)*	Electric and steam.
— 25	1 d. — 1 up.	Pullman—Sud Express.	273 *(268.7)*	Electric and steam.
— 05	2 d. — 1 up.	Standard metal coaches.	500 *(492.1)*	Electric.
- 25	1 d. — 1 up.	Bugatti triple railcar.	—	Railcar.
— 30	2 d. — 2 up.	Franco-Belge triple railcar.	—	Railcar.
— 02	1 d. - 1 up.	400 or 800-H.P. Bugatti single railcar.	—	Railcar.
— 47	1 d. — 1 up.	ABV Renault double railcar.	—	Railcar.
...	35 trips.	Twin and triple streamlined electric sets.	367 *(361.2)*	Electric.
...	85 trips.	Electric motor coaches and trailers.	300 *(295.2)*	Electric.
...	5 trips.	Diesel-electric triplets.	200 *(196.8)*	Railcar.
...	3 trips.	Metal coaches.	315 *(310.2)*	Steam trains.
...	30 trips.	Wooden-bodied coaches.	230 *(226.4)*	Steam trains.
- 15	1 d. — 1 up	Triple-unit electro-trains.	—	Electric.
— 59	1 d. — 1 up.	Do.	—	Electric.
— 03	2 d. — 2 up.	Do.	—	Electric.
— 35	1 d. — 1 up.	Do.	—	Electric.
— 47	2 d. — 2 up.	110-seater railcar.	—	Railcar.

gines which are particularly suitable for greatly speeded up services owing to their good qualities as regards starting, maximum speed and braking.

Single and double units are used for the local services and semi-express services, specially designed single and double units for the express services, three- and four-unit cars for all the local services and fast services over all routes (secondary, suburban and main lines).

(b) Use of new types of engines : steam locomotives improved from the point of view of speed and power, or of new types; single or multiple diesel locomotives, which are now as powerful as the steam locomotives;

(c) Reduction of the train weight (reduction of the number of coaches or use of light metal coaches);

(d) General improvement of the permanent way and signalling plant, renewal or strengthening of the track, corrected layout where necessary, elimination of special points that can only be passed at reduced speed, etc.

(e) Improvement of the operating technique (improvement of the traffic regulations; forbidding goods wagons being hauled by passenger trains; shortening stops; provision of new train connections at junction points, etc.);

(f) Systematic closing of intermediate passenger stations; in Holland, 148 stations have been completely closed;

(g) Electrification of certain lines, with or without a radical alteration of the operating conditions (Brussels-Antwerp, Paris-Bordeaux-Hendaye, Bologna-Florence, Rome and Naples).

On the Brussels-Antwerp line, a new double track has been built in order to separate the electric traffic from the steam traffic. The electric line is composed of old and new sections. On the old sections the superelevation on curves had to be increased owing to the fact that the specialised services consisting entirely of fast passenger trains took the place of a mixed traffic (both fast and slow); the transition curves have been made longer; the level crossings were replaced by under- or over-bridges. Through Malines, the only case of the kind, the electric line had to be diverted in order to avoid the swing bridges.

The speeding up of the services has generally been accompanied by an increase in the speed at which the trains *actually run.*

In many cases the maximum authorised speed also had to be increased, as shown hereafter :

Belgium. — Increased from 100 to 120 km. (62 to 75 miles) an hour on the Brussels-Namur line, and from 120 to 140 km. (75 to 87 miles) an hour on the Ghent-Bruges line. For the future, a speed of 150 km. (93 miles) an hour is under consideration.

France. — Increase to 130 km. (81 miles) an hour for certain steam and electric trains on sections equipped with the automatic block.

Increase to 140 km. (87 miles) an hour for high-speed railcars (150 km. = 93 miles an hour on sections equipped with the automatic block).

Holland. — Maximum speed increased to 140 km. (87 miles) an hour; a speed of 160 km. (100 miles) is under consideration.

Italy. — The speed limit has been increased to 160 km. (100 miles) an hour on the electrified sections, Rome to Naples for example.

Rumania. — Increase to 110 km. (68 1/2 miles) an hour and in the near future to 120 km. (75 miles) an hour; in 1934 the speed limit was 100 km. (62 miles) an hour.

In certain cases, particularly on lines carrying heavy traffic, the speeding up of the passenger services has much interfered with the *goods services :*

In Belgium several goods trains have had to be diverted to other lines; the weight of some trains has been reduced owing to the speeding up of their timings, whilst others which could neither be diverted nor speeded up have had their timings extended,

owing to the greater number of times they have to be overtaken en route. In addition certain optional services have been cancelled and certain intermediate stations are now served during the night by local goods trains.

In France, this speeding up generally speaking has not had any great effect on the capacity of the lines. On most of them, in fact, the putting into use of sidings which can be run into through facing points and the speeding up of the through goods trains enabled new express passenger services to be introduced without cancelling any of the goods trains; on the Paris-Rouen line, however, the increase in the number of services made it necessary to cancel certain optional day trains, and to work by night most of the regular goods trains, in particular the local goods train services.

In Holland, no special difficulties were encountered; the goods trains run by night, whereas passenger services are only run by day.

* * *

CHAPTER II.

Improvements to the rolling stock and fixed plant.

(A) Motive power and rolling stock (railcars excepted).

In this Chapter we will investigate the following points in succession :

1. Increased power of the engines : It should be noted that such increase had already become indispensable as a result of the increased train weights due to the use of metal coaches;

2. Reduced tare weight of the metal coaches compared with the early designs; correlatively lighter train composition;

3. Improvements in the brakes equipping the power units and rolling stock in order to assure the trains being stopped safely within the signal location limits.

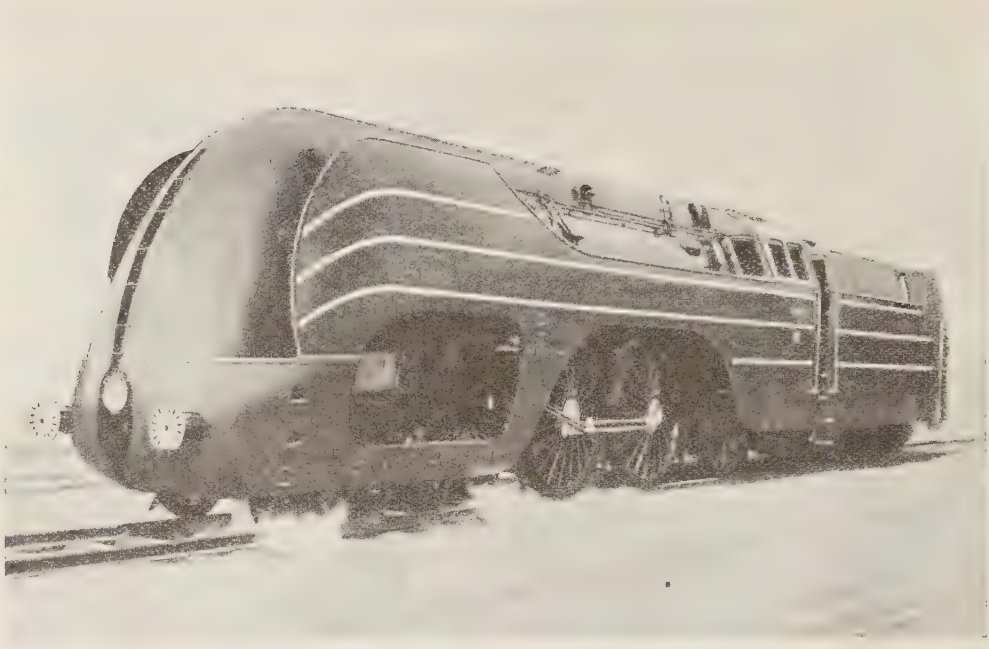
1. Increased power of the engines.

Table C gives certain traction charac-

TABLE C. — **Traction characteristics of locomotives.**

Traction characteristics of steam engines or electric locomotives *before* and *after* acceleration of the services.	France. — *National Rys. Co.*						Rumania.		
	Steam traction (Paris-Belfort) on the level.			Steam traction (Paris-Belfort) on 1 in 167 gradient.			Steam traction on the level.		
	Before acceleration.	After acceleration.	Increase, %.	Before acceleration.	After acceleration.	Increase, %.	Before acceleration 1934.	After acceleration 1938.	Increase, %.
Horse-power per ton hauled	1.67	2.02	21	2.4	2.84	18	2.8	3	7.2
Horse-power per seat available	1.74	2.10	21	2.5	2.95	18	—	—	—
Hourly evaporation in kgr./m² *(in lb. per sq. foot)* of total heating surface.	41 *(8.4)*	49 *(10.0)*	19.6	49 *(10.0)*	58 *(11.9)*	18.4	55 (1) *(11.3)*	65 (1) *(13.3)*	18.3
Hourly coal consumption in kgr./m² *(lb. per sq. foot)* of grate area.	310 *(63.5)*	380 *(77.8)*	22.5	380 *(77.8)*	450 *(92.2)*	18.5	400 (1) *(81.9)*	500 (1) *(102.4)*	25

(1) Maximum figures.



Atlantic type class 12 locomotive of the Belgian National Rys. Co.

The « Etoile du Nord » (Northern Star) hauled by streamline *Pacific* locomotive No. 3.1280. — French National Rys. Co., Northern Area.

Streamlined train No. 3, of the French National Rys. Co. (South-Eastern Area), leaves the Gare de Lyon (Paris).

teristics for locomotives before and after the speeding up of the services, as well as the percentage increases in the power and in the fuel and water consumption, the latter being about 20 %.

We will deal in turn with :

Steam traction :

The new designs under construction;
Completely or partially converted locomotives;
Streamlining of existing or new locomotives.

Electric traction :

The possibilities offered by electric locomotives, which at present are more powerful than steam locomotives.

Diesel traction with locomotives :

We will deal with the most interest-

Streamlined train No. 3, of the French National Rys. Co. (South-Eastern Area), leaves the Gare de Lyon (Paris).

ing new designs put into service recently.

Steam traction.

New designs.

After the type 1 *Pacific* was put into service in 1935, Belgium ordered six *Atlantics* of new design, intended to haul steam trains at a speed of 150 km. (93 miles) an hour. The *Atlantic* type was selected owing to its good riding qualities. Diameter of wheels : 2.10 m. (6' 10 11/16"). Streamlining, with Huet deflectors. These engines have just been delivered.

In addition, the Belgian National Rys. Co. is building 4 tank locomotives for mixed services on secondary lines; these engines, which only weigh 36 t. (36.4 Engl. tons) in working order, will be delivered in 1939; they will be driven by a single man.

At the present time in France the following new designs are under construction :

(a) *60-Hpz (870 lb./sq. in.) high-pressure (S. A. C. M.) locomotives.*

60-Hpz (870 lb./sq. in.) water tube boiler fed by a 20-Hpz (290 lb./sq. in.) boiler working with untreated water. Engines working with 60-Hpz steam pressure, 2 engines for each of the three pairs of driving wheels. Each 500-H.P. engine has 3 cylinders, 150 mm. (6 in.) bore, and 255 mm. (10 in.) stroke, of the poppet valve uniflow type.

Engine speed up to 1 000 r.p.m.

Gear and quill drive.

4-6-4 wheel arrangement, driving wheels diameter 1.55 m. (5' 1").

New boiler and motion, but the boiler is coal- and grate-fired, and the draught is obtained through the conventional exhaust arrangement.

(b) *Turbine locomotive (Schneider).*

Conventional boiler, 25 Hpz (363 lb./sq. in.).

Three turbines drive individually the three pairs of driving wheels through two sets of symmetrical gears, with flexible transmission of the rotary movement to the axle.

Each turbine, of very small size, can run at 10 000 r.p.m. and develop nearly 1 000 H.P. The three turbines can work independently of each other (graduation of the total power).

Circulation of oil under pressure through all the motion (by turbo-pump, or when running without steam by means of a mechanical pump driven by the wheels).

4-6-4 wheel arrangement.

(c) *Locomotive with drive through a longitudinal shaft (Dabeg-Batignolles).*

Boiler of the usual type.

16-cylinder Vee engine at the leading end lengthwise along the centre line; can run at 1 000 r.p.m. — Uniflow.

The longitudinal shaft drives through a worm gear in an oil-tight case a quill round each driving axle, a spring drive being introduced between the quill and the axle following the design now classic in electric locomotives.

Power 1 200 H.P. on two pairs of driving wheels.

(d) *Locomotive with Velox boiler (C.E.M.).*

Velox boiler, fitted on the frame of an old 4-6-0 engine. Engine and motion of the classic type. Oil-fired boiler.

It takes only 15 minutes to get up steam.

The efficiency reaches 83 to 86 % compared with 65 to 70 % for an ordinary type of boiler.

Steam output 12 tons per hour, of which 1 ton at most is required to work the auxiliaries.

The complete evaporative group has been installed in the place occupied by the old boiler, although it includes the combustion air compressor (1.5 kgr./cm^2 = 21.3 lb./sq. in.) operated by a turbine worked by the exhaust gases.

This locomotive has already hauled 580-t. (570 Engl. tons) trains between Paris and Laroche. It will only be possible to say after lengthy trials if the evaporative group is sufficiently robust to stand up to railway service, especially when fed with untreated water.

(e) *Hudson 4-6-4 locomotive (specially designed by the former O. C. E. M.).*

Boiler and motion of the classic type, designed to get the maximum strength and life. The 4-6-4 wheel arrangement gives greater freedom in choosing the dimensions of the grate, to get a lower rate of combustion per unit of area.

Eight such locomotives will shortly be put into service.

Complete or partial conversion of steam locomotives.

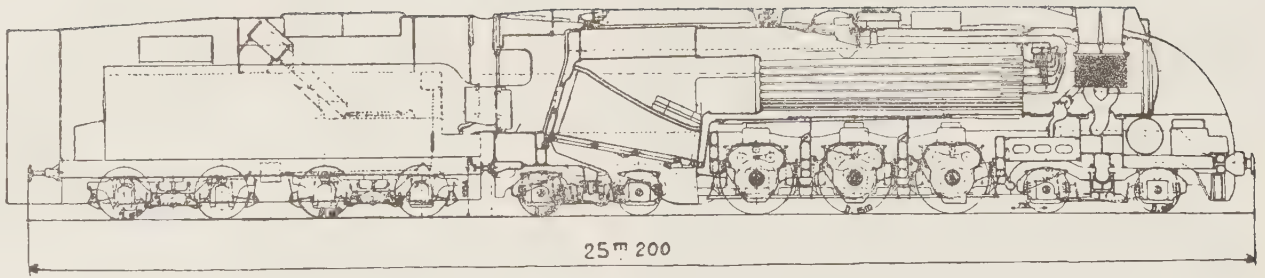
An extensive programme for the conversion and modernisation of French steam locomotives has been carried out, more attention being paid to the thermodynamic efficiency than to the mechanical efficiency which was already of about 90 to 95 %. At the same time the capacity of the tenders was increased to 35/38 m^3 (7 700 to 8 360 Br. gall.) so that non-stop runs of about 350 km. (220 miles) can be made in express service.

The alterations mainly covered three distinct points :

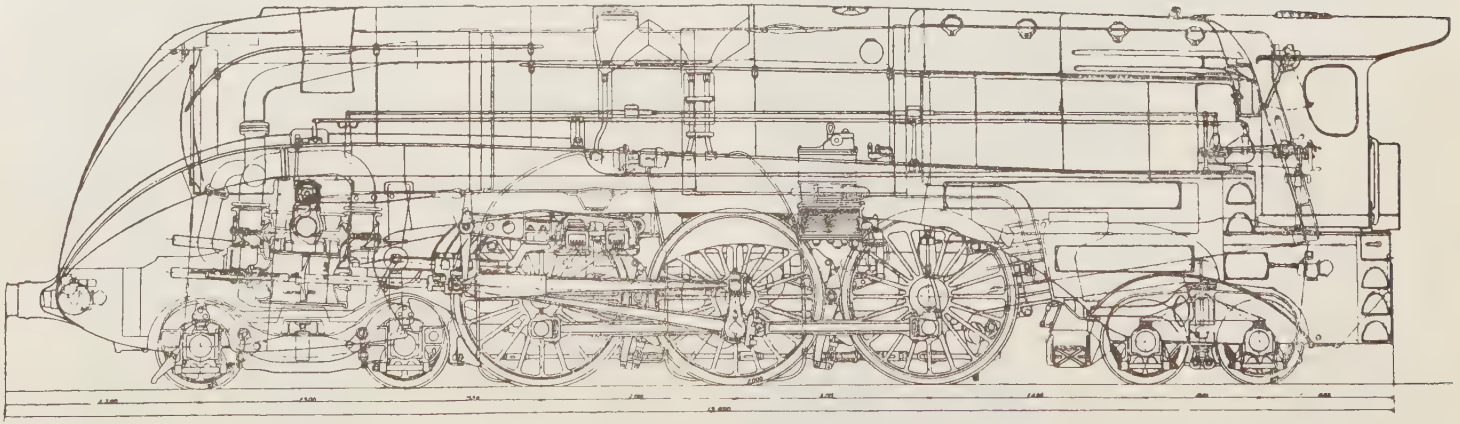
1. Improvement of the exhaust which has made it possible to lower the back pressure in the cylinders to 1/2 — 1/3 of the former figure;

2. Increase in the superheat temperature from 300° to 400° C. (572 to 752° F.);

3. Increase in the sections of the steam passages, which have been practically doubled, in order to reduce the pressu-



4-6-4 turbine locomotive under construction at the Schneider Works.



« Hudson » 4-6-4 type locomotive being built for the French National Rys. Co. (Northern Area).

re losses in the piping and the wire-drawing action through the steam ports;

These modifications, according to the case in question and type of locomotive to which they were made, led to two kinds of alterations :

(a) Complete conversion (Pacific type locomotive of the P. O. and the P. L. M. — 231-H—), incorporating all the desirable improvements and which, in the case of the Paris-Orléans old compound *Pacifics,* for example, meant replacing the cylinders, rods, crank axle, exhaust, tube plates, superheater, fire-box, and the provision of mechanical lubrication of the cylinders and axle boxes and of a feed water heater.

The cost of this complete alteration at 1938 values was approximately 1 million francs, i.e. 50 % of the present cost of building a completely new locomotive.

(b) Partial conversion [certain *Pacific* type locomotive of the P. O. and the Ouest, Est, P.L.M. (231 G)], which in the case of the same P.O. *Pacifics,* for example, merely consisted in replacing the low-pressure cylinders, driving rods, crank axle, exhaust, superheater, and the application of mechanical lubrication to the cylinders.

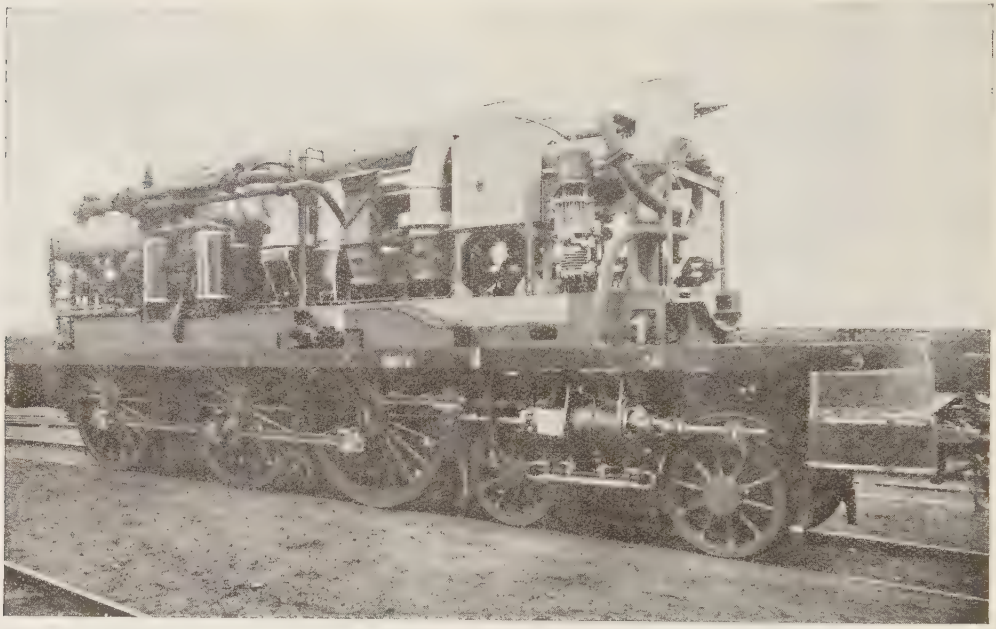
The cost of this partial conversion in present values is approximately 400 000 francs i.e. 20 % of the present cost of a new engine.

Streamlining steam locomotives.

A great many Companies have made various trials of streamlining in recent years in order to improve the speed or reduce the consumption figures of steam locomotives. The general opinion is that streamlining gives really interesting results when speeds of 100 km. (62 miles) an hour and over have to be maintained for long periods.

The trials carried out with a P.L.M. streamlined train consisting of four streamlined coaches hauled by a 1907 streamlined *Atlantic* locomotive which had been fitted with a superheater, a new exhaust and feed water pre-heater, showed that at 140 km. (87 miles) an hour the power was increased by 25 % and the saving in water and fuel was a little greater, compared with the locomotive before streamlining.

Results.	*P.O.* Original Pacific.	*P.O.* Pacific after complete conversion.	*P.O.* Pacific after partial conversion.	Improvements obtained by		Gain with complete conversion as compared with partial conversion.
				complete conversion of original locomotive.	by partial conversion of original locomotive.	
Maximum drawbar H.P. in continuous working at 110 km. (68.3 miles) an hour	1 450	2 650	2 000	+ 83 %	+ 38 %	+ 32.5 %
Consumption of 7 950 cal./kgr. (14 300 B.T.U./lb.) coal for 1 450 H.P. at the drawbar, kgr. *(lb.)* of coal per H.P.-hour . . .	2.40 *(5.29)*	1.10 *(2.43)*	1.22 *(2.69)*	— 54 %	— 49 %	— 10 %



VELOX boiler mounted on the frame of an existing 4-6-0 type locomotive.

On the other hand, the streamlining of a P.O. type *Pacific* locomotive only increased the power at the drawbar by 150 H.P. at 130 km. (81 miles) an hour (i. e. about 10 %), though this made it possible to haul an additional 50-ton bogie carriage.

The cost of altering the P.L.M. *Atlantic* locomotive was 131 000 fr. for streamlining the engine (8 % of its present-day price), 76 000 fr. for streamlining the tender (25 % of its price at present) and 138 000 fr. for all the other alterations.

These alterations made it possible to work the Paris-Lyons service (500 km.= 310 miles) at 100 km. (62 miles) an hour overall speed with a 200-t. (197 Engl. tons) streamlined train.

From the maintenance point of view, the streamlining of steam locomotives when carried out on old locomotives always has some drawbacks, as it is not possible to make a sufficient number of inspection covers to get at all the parts of the locomotive very easily.

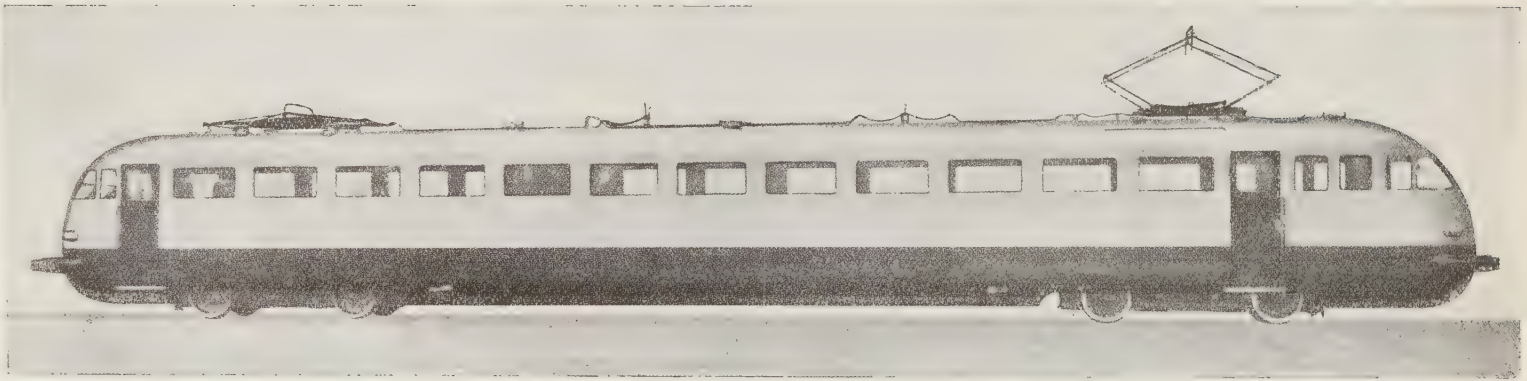
Usually the motion is left uncovered, which makes it easier to inspect it and prevents overheating of the inner parts, especially the low-pressure motion of the locomotive.

Maintenance difficulties are reduced when the streamlining is applied to new locomotives. It is then possible to arrange the pipes in groups and concentrate the inspection points, which reduces the number of inspection covers required.

Electric traction.

As regards *electric traction*, the locomotives put into service on lines which have been electrified, have been designed with ample reserve power compared with the steam locomotives they replac-

BREDA streamline electrotrain for 3 000-volt direct current.



BREDA motor coach for 3 000-volt direct current.

ed. In the present state of technical knowledge, express electric locomotives give an excellent output over a wide range of speeds.

Most railways endeavour to use their tractive power to a maximum, and they haul very heavy (700 to 800-ton) trains at the maximum authorised speed). With less heavy trains (400 to 500 tons), full use cannot be made at present of their speed capacity, owing to the fact that the speed is limited to 120-130 km. (75 to 81 miles) an hour.

In France and Italy, the working of electric locomotives at 150 km. (93 miles) an hour and over is still being investigated (lateral stabilisation of the bogies or guiding trucks).

Amongst the most recent electric locomotives and motor coaches mention may be made of the following :

In Italy :

The *Breda* so-called « Electrotrains » consisting of 3 coaches carried on 4 bogies, and the electric motor coaches built and put into service since 1937 following the rapid extension of the electrification programme with 3 000-volt direct current.

The « Electrotrain » is used for through services between large towns; its speed in service is 150 km. (93 miles) an hour. [During its trials on the 7th December, 1937, it reached the record speed of 202 km. (125.5 miles) an hour.] Its tare is 105 t. (103.3 Engl. tons) and it has six 1 500-volt 250-H.P. motors completely spring borne with quill drive and double reduction gear.

The electric motor coach is intended for semi-express services or for pick-up services on the main lines; its working speed is 120 km. (75 miles) an hour.

In Holland :

The extension of electrification (15/5/38) to the Utrecht-Amsterdam, Utrecht-The Hague, Utrecht-Arnhem, Utrecht-Eindhoven and Rotterdam-Gouda lines (275 km. = 170.9 miles), made it necessary to put into service 53 twin-car articulated sets weighing 79 t. (77.75 Engl. tons), and 37 non-articulated triple-car sets weighing 144 t. (141.7 Engl. tons), all streamlined, with a nominal maximum speed of 125 km. (77.7 miles) an hour (maximum speed of 150 km. = 93 miles an hour reached during the trials).

The twin-car sets can be coupled up as multiple units of 8 or more. This makes their use very flexible, since peak traffic can be dealt with at the fast booked timings.

In France :

The 2 D 2 *electric locomotive* selected for hauling the semi-express and express passenger trains on the Paris-Le Mans line, electrified at the beginning of 1937, was the locomotive used since 1925 by the former P.-O. System [Compagnie Electro-Mécanique — 4 000 H.P. — 130 t. (127.9 Engl. tons)]. It is to be noted that it was lightened by the removal of the regenerating equipment which was useless on the easy gradients of the Le Mans line, and that it is streamlined. This locomotive is able to haul 600 t. (590 Engl. tons) at 140 km. (87 miles) an hour, and for the last 18 months and more has covered the 211-km. (131.1 miles) Paris-Le Mans run in 2 hours 5 minutes.

16 new 2 D 2 electric locomotives have been ordered for the Paris-Bordeaux new electrified main line. Three have already been delivered, and during recent trials a speed of 160 km. (100 miles) an hour was reached by a locomotive hauling a train of 300 t. (295 Engl. tons). The 112 km. (69.6 miles) run between Les Aubrais (Orléans) and St.-Pierre-des-Corps (Tours) was covered in 51 minutes at 150 km. (93 miles) an hour with several speed restrictions, i.e. at an average speed of 132 km. (82 miles) an hour.

These locomotives are intended to haul 800-t. (787 Engl. tons) trains at 130 km. (81 miles) an hour.

Successive shapes of the front end of electric multiple-unit trains, Netherlands Railways.

A double motor coach with stainless steel body, for outer suburban traffic, has the following characteristics :

— 2 bodies in stainless steel welded by the Budd process.

— 3 bogies, each pair of wheels being equipped with a motor so that the total adhesion makes it possible to get accelerations of about 1 m. (3.3 ft.) per sec. per sec.

— Tare : 74 t. (72.8 Engl. tons).

— Capacity : 130 passengers seated; 170 passengers standing at rush hours.

The maximum speed of 155 km. (96.3 miles) an hour was reached during the trials with satisfactory running stability; the 211 km. (131.1 miles) between Paris and Le Mans, with 9 intermediate stops, can be covered in 2 hours.

The diagram hereafter shows the accelerating aptitude of this motor coach compared with that of the coach for pick-up services described below and the 2D2 electric locomotive in service on the Paris-Le Mans line.

A single motor coach for pick-up services on the Paris-Le Mans line — built by Messrs. *Alsthom-Somua-Oerlikon* — has a tare of 40 t. (39.4 Engl. tons), can carry 80 passengers seated and 70 standing in rush periods; its acceleration is 1 m. (3.3 ft.) per sec. per sec.). Trials in service exceeded expectations; the running was excellent up to 170 km. (105.6 miles) an hour, and a speed of 155 km. (96.3 miles) an hour can be maintained continuously.

The diagram hereafter gives some idea

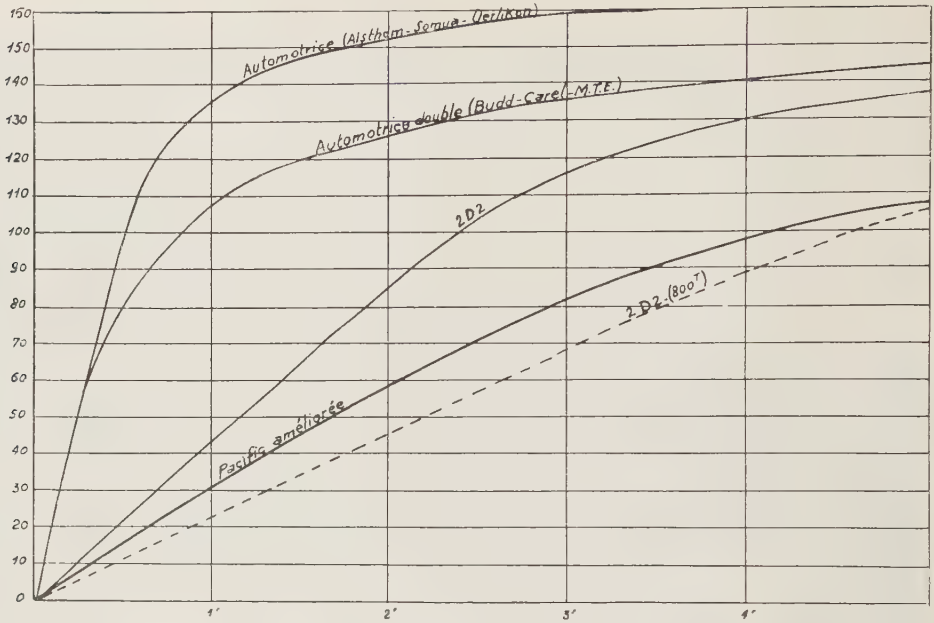


Diagram showing the comparative accelerating power of the *Alsthom-Somua* pick-up single electric motor coach, the twin electric motor coach of stainless steel, a 2 D 2 (4-8-4) electric locomotive hauling a 400-t. (393.7 Engl. tons) train, and a *Pacific* steam locomotive hauling a 400-t. train.

Explanation of French terms:

Vitesses en km./h. = speeds in km.p.h. — Automotrice double = twin electric motor coach. — Pacific améliorée = improved Pacific. — Nota, etc. = in the case of locomotives, the full-line curves refer to hauled loads of 400 t.

of the accelerating powers of this stock. The braking characteristics are equally interesting: the coach can be stopped in 33 seconds from a speed of 130 km. (81 miles) an hour in 650 m. (710 yds).

The Paris-Le Mans run (211 km. = 131.1 miles) takes 2 hours 3 minutes with 17 intermediate stops.

The electrification of certain main lines has made it possible (France, Italy, Holland) to transfer powerful locomotives (France, Italy) or multiple-unit railcars (Holland) to lines not so well equipped so far, thereby making possible considerable speeding up of the service.

Diesel traction.

As regards the use of *diesel locomotives* of high power, at the moment we can report only relatively limited applications. Both examples relate to very powerful engines, and are particularly interesting.

In France:

Since the beginning of 1938, the French National Rys. Co. has owned two diesel electric locomotives. These two locomotives whose total weight, including fuel and stores, is 225 t. (221.4 Engl. tons) each consist of two identical units of the 2-Co-2 type coupled together and have a continuous power of about 4 000 H.P. on the diesel shaft.

The locomotives were ordered in order to not only to haul regular 600-t. (590 Engl. tons) passenger trains over long distances to the present timings, but also to work a

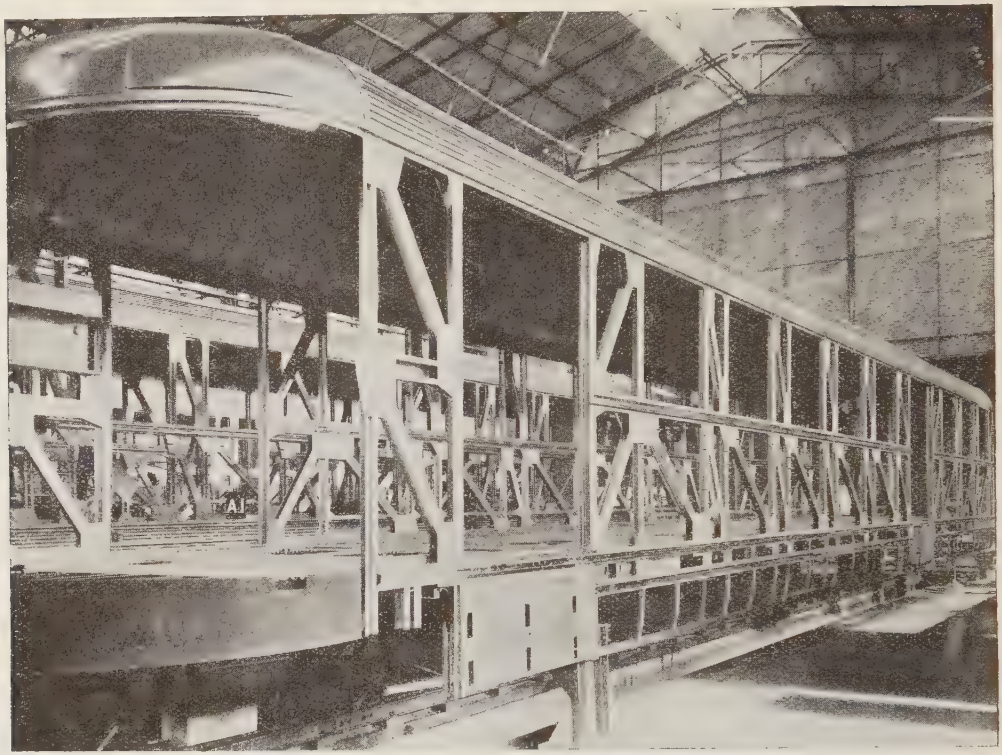
High-speed electric motor coach built of stainless steel, French National Rys. Co. (Western Area).

service between Paris and Mentone (1 111 km. = 690.3 miles) without refuelling, hauling a train of 450 t. (442.9 Engl. tons) at an average speed of 100 km. (62 miles) an hour, the maximum speed allowed being increased to 130 km. (81 miles) an hour over the greater part of the run.

A daily speeded up service between Paris and Nice being impossible with only two locomotives, the two diesel locomotives are at the present time used to haul the heavy express and semi-express trains between Paris and Lyons and back (2 × 510 km. = 633.8 miles), which they do very satisfactorily in one day, with an interval of 3 hours 20 minutes in the Paris depot for refuelling, greasing, and summary inspection. The first locomotive to be delivered has just come in for repairs after a mileage of 150 000 km. (93 000 miles), while the second has already run more than 100 000 km. (62 000 miles).

In Rumania, an articulated diesel-electric locomotive with two 2 200-H.P.. engines was delivered at the end of 1938; it differs from the two locomotives put into service by the South-Eastern Area of the French National Rys. mainly by having 8 driving pairs of wheels instead of 6 (2-Do-1 + 1-Do-2).

This locomotive is intended to haul 600-t. (590 Engl. tons) trains on the Bucarest-Brasov main-line; this mountain line car-



Body framing of electric motor coach built of stainless steel, French National Rys. Co. (Western Area).

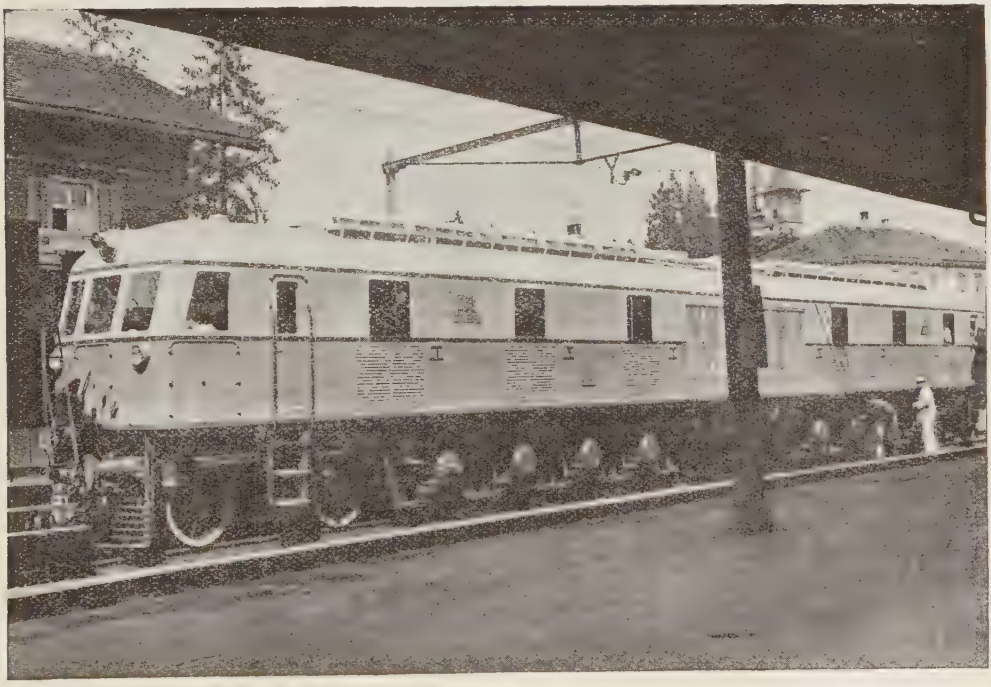
rying heavy traffic links up Bucarest with Hungary and Central Europe through the Transylvanian Alps. An altitude of 626 m. (2 054') is reached in 49 km. (30.4 miles), so that the average gradient is approximately 1 in 77; in the other direction, it is still steeper, with 6 km. (3.7 miles) on a 1 in 50 gradient and 20 km. (12.5 miles) on a 1 in 40 gradient. The booked average speed for hauling a 600-t. train is 60 km. (37.3 miles) an hour between Bucarest and Brasov. Great savings can be expected from the use of this diesel when it is remembered that four locomotives are often required to haul heavy trains on this line, two at the head and two at the tail.

In addition, we may mention that in France plans are under consideration for building a new type of 3 000-H.P. diesel locomotive suitable for both passenger and goods services, of the 2 D 2 or 2 E 2 (4-8-4 or 4-10-4) type, which doubtless will be the most powerful diesel locomotive in the world.

2. **Reduction of the tare of metal coaches as compared with early types. — Lightening the composition of trains.**

On the main lines, train acceleration has coincided in recent years with the general use of metal coaches, that is to say with heavier trains. The existing locomotives have therefore had to make a double effort, at the cost of considerable maintainance expenses.

4 000-H.P. diesel locomotive of the French National Railways Co. (South-Eastern Area) (formerly P. L. M.) exhibited at the « Gare de Lyon » (Paris).



4 400-H.P. SULZER diesel-electric locomotive, Rumanian State Railways.

On the other hand, on the secondary lines, partly abandoned by passengers, the existing locomotives have been able to haul accelerated trains of reduced composition without any additional effort.

On the main lines, as well as on the others, the Railways now endeavour to reduce the effort, and consequently the wear and tear of their locomotives by reducing the dead weight of their new coaches.

We wish to specially mention the semi-indeformable streamlined and particularly light coach sets (Société Charentaise) for steam traction [Paris-Havre, 420 t. (413.4 Engl. tons) compared with 500 to 700 t. (492 to 689 Engl. tons)] and some electric coach sets, in particular the Italian and Dutch sets.

We have already described the electric coach sets; we will revert later on to the rolling stock for steam trains.

Lightened train composition has only been used in certain cases.

Let us mention, for example the Italian light 2-coach trains [70 t. (68.9 Engl. tons) drawn by a locomotive capable of hauling 220 to 300 tons at 70 km. (43.5 miles) an hour on the level]. The number of services is increased, which makes it possible to reduce the number of seats available in each train and the load to be hauled. The gain in speed made possible with such « light trains » doubles the interest of the alteration in the service of the line.

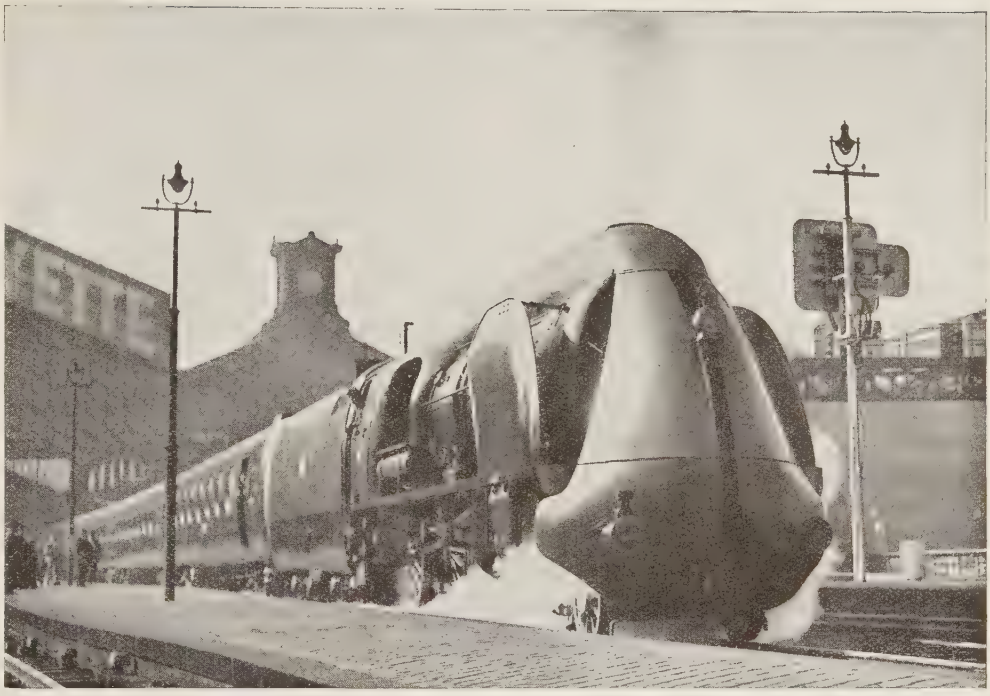
The same process has been extended to services over average distances with particularly paying traffic, and even to high-speed long-distance trains, such as the Paris-Marseilles train shown in Table B (pp. 572-573).

The introduction of such trains has, however, remained very limited. If accompagnied, as is often the case, by the use of special stock (old coaches with streamlined body), their multiplication (and even maintaining them in service over long periods) introduces complications due to the use of special non-interchangeable stock.

Amongst the most interesting results obtained as regards lightening metal coaches during recent years, we will mention certain applications on the French Railways (Eastern, Western and Northern Areas).

The lightened *suburban* stock designed and put into service in 1937 on the Eastern Area weighs 31.5 t. (31 Engl. tons), a saving of 10 t. (9.8 Engl. tons) compared with the original coaches.

The general design is the same as that of the other coaches of the Eastern Area, i.e. tubular construction of the body-frame unit; investigations were directed on the use of high-tensile steels making it possible to use thinner plates; bogies with monoblock cast steel frame were designed so as to reduce the spring-borne and unsprung weight (the axles were bored out, and the thickness of all the cast steel parts reduced); in addition, the interior arrangement was based on the same principles: use of aluminium or aluminium alloys for the panelling of the walls and for the mouldings, use of light metals for the brasswork, use of plywood or Isorel for the flooring, etc. It should be noted that this lightening in no way affected the comfort or safety, as the method of construction employed, which is quite contrary to the old idea of static frames composed of a general trellis with all the stresses localised at the joints, is that of a tube closed throughout, and composed of plates connected together by welding with inside stiffeners represented by closed section spigot-jointed cross braces having a high moment of inertia; the roof itself forms, owing to its anchoring to the sides and its bracing, an upper duplicate of the safety arrangements made at the lower part of the underframe; this latter point is to be stressed, as it should do away with one of the aggravating circumstances in case



Streamline train with light-weight coaches built by Messrs. Entreprises Charentaises for the French National Rys. Co. (Western Area).

of collision : telescoping owing to the breaking and bursting away of the upper connections of the body.

For its *main-line* coaches now under construction, this same Area has made arrangements identical with those on its suburban stock with which we have just dealt. The tare of these coaches is approximately 39 tons, i.e. a lightening of more than 18 % in comparison with the coaches now in service which weigh 48 t. (47.2 Engl. tons).

The Western Area has some lightened main-line stock due to the collaboration of the « Société des Entreprises Charentaise ». An A^8 coach of this new type weighs about 35.5 t. (35 Engl. tons). The body framing-under frame unit is made of special steel with high mechanical characteristics (65 kgr./mm^2 = 43 tons/sq. in.) tensile strength, which has made it possible to make the plates thinner; this new type of framing is of oval section, and consists essentially of a ribbed fuselage, cross-braced in the horizontal plane by a steel trellis in conjunction with a series of vertical trellis girders, the top parts of which act as the intermediate cross bearers whilst the bottom parts carry the streamlined walls. The body framing is cross-braced by a series of rings of bent plate forming a closed section; the two strongly reinforced box shaped ends complete the cross-bracing of the whole unit, which has two solebars and two deck sills like the normal construction.

The Northern Area, which has had several years' experience of welded steel construction, has built a *suburban articulated set* of 3 coaches on 4 bogies in the bodies of

which extensive use has been made of aluminium alloys, also welded, the frame itself being of ordinary steel. The latter consists of a main girder in itself strong enough to resist all the stresses, as the body adds nothing to the strength of the whole unit. The ends are reinforced by a thick plate and two vertical members. The saving in weight obtained in this way is 37.5 % in comparison with a similar construction in steel throughout.

For future orders, the French National Rys. Co. intends to build vehicles whose general characteristics will agree with those of the Eastern Area design described above, and be of the lightened type, with a tare of about 39 t. (38.4 Engl. tons) for coaches not equipped for electric heating.

3. Improved brakes.

The Report which M. Jean LEVY and the Author wrote for the Paris Session (1937) of the International Railway Congress Association, gave a detailed account of the braking question, and in particular of the various tests made to obtain better use of the adhesion and reduce the stopping distances.

Most of the devices mentioned in that report were tested first of all on railcars and have since been applied to trains hauled by steam locomotives. Table D gives the results obtained with steam trains equipped in this way, but the test conditions vary from one test to another and are not comparable.

A few words will be said here of the new brakes which have not been described.

Poncet brake.

This method has two brake powers : one at high pressure for high speeds, and the other at low pressure for lower speeds. The change over from one to the other takes place automatically by means of a single centrifugal regulator mounted on the locomotive. This regulator can be regulated to work at the speed after which the coefficient of friction begins to increase appreciably.

Houplain brake.

This brake is designed on the same principle as the Westinghouse self-regulating brake, and only differs from it in the way the design has been worked out. In particular the two cylinders on the Houplain brake are fed from a single reservoir. Investigations are still in hand to make this brake non skidding.

The Belgian National Railways Co. is equipping 6 triple railcars, to be put into service in 1939, with the Westinghouse self-regulating high-pressure brake. The Westinghouse automatic self-regulating brake will also be fitted on 6 *Atlantic* locomotives, 8 twin electric coaches, and 120 coaches for international service, all of which are to be put into service by the Belgian National Railways Co. in 1939. The same Administration for experimental purposes is mounting a Pieper self-regulating brake on several coaches for home service.

The Italian State Rys. have also improved the brakes on trains running at more that 120 km. (75 miles) an hour, by means of devices which make it possible to use brake coefficients of more than 100 % during the first phase of application.

(B) Fixed plant and signals.

As regards the fixed plant and signals, the speeding up of the passenger trains has been made possible by the following measures :

1. Careful maintenance of the permanent way; adapting it to the speed to be run;

2. Elimination of special points requiring speed restrictions; improvement of facing points run over onto the branch line.

TABLE D.

Stopping distances obtained with various modern brakes equipping steam or electric trains.

Country.	Description of brake.	Composition of test train.	Total train weight Metric *(Engl.)* tons.	Stopping distance from 120 km. *(75 miles)* p.h. Metres *(Yards)*.	Stopping distance from 140 km. *(87 miles)* p.h. Metres *(Yards)*.	Gradient.	Remarks.
FRANCE. — *National Rys. Co.*	Brake with double cast iron shoes.	Locomotive, tender, dynamometer car, 6 metal coaches.	511 *(502.9)*	890 *(973)*	1 264 *(1 382)*	On the level.	...
	Brake with Flertex single shoes.	Locomotive, tender, dynamometer car, 6 metal coaches.	511 *(502.9)*	1 002 *(1 096)*	1 532 *(1 675)*	On the level.	Locomotive braked and dynamometer car cut out.
	Brake with Flertex double shoes.	Locomotive, tender, 7 metal coaches.	493 *(485.2)*	637 *(697)*	739 *(808)*	falling 1 in 200.	...
	Piganeau brake with double shoes.	Locomotive, tender, 4 metal coaches.	332 *(326.7)*	670 *(723)*	870 *(951)*	falling 1 in 200.	...
	Westinghouse self-adjusting brake with double shoes.	Locomotive, tender, 4 metal coaches.	332 *(326.7)*	615 *(672)*	840 *(918)*	falling 1 in 200.	...
	Poncet brake with double shoes.	Locomotive, tender, 3 metal coaches.	290 *(285.4)*	650 *(711)*	860 *(940)*	On the level.	...
	Houplain brake with double shoes.	Locomotive, tender, 4 metal coaches.	372 *(366.1)*	720 *(787)*	1 010 *(1 104)*	On the level.	...
	N. R. brake with double cast iron and Flertex shoes.	2D2 electric locomotive, 7 wooden-bodied coaches with plate sheathing.	380 *(374.0)*	690 *(755)*	950 *(930)*	On the level.	Locomotive braked.
	N. R. brake with double cast iron and Flertex shoes.	2D2 electric locomotive, 10 wooden-bodied coaches with plate sheathing.	492 *(484.2)*	660 *(722)*	905 *(990)*	On the level.	Locomotive braked.
ITALY.	Brake for high speeds.	Electric locomotive E 428 and 14 coaches with brake for high speeds.	—	725 *(793)*	1 080 *(1 181)*	On the level.	Locomotive braked with standard brake.
	Brake for high speeds.	3-coach Breda « Electrotrain ».	—	740 *(810)*	1 050 *(1 148)*	On the level.	...
				from 81 m.p.h.	from 93 m.p.h.		

NOTE. — The conditions under which the tests were carried out in France and Italy are not comparable.

Three-coach electric set, Netherlands Railways.

3. Improvement of the signals, using day-light signals in certain cases.

1. **Permanent way maintenance.**

The speeding up of the trains has generally been preceded by putting the permanent way in good order, after trials made at high speed in order to find out the chief defects to be corrected. These are generally defects of alignment or level which did not affect slower workings, and which did not cost much to correct.

The lack of superelevation on the curves and their parabolic transitions has been calculated; the curves and transitions have been checked over; the transitions have been made as long as the locations allowed.

Speed restrictions have been imposed on certain curves where the superelevation is too small for the speeds in view, in order to avoid having to move them outside the old formation.

Most of the Administrations consulted consider that once the track has been put into good order, the maintenance costs are approximately the same before and after the speeding up of the services. It should, however, be noted that in Rumania the inspection of the track is more frequent and more rigorous than formerly, and the Italian State Railways find it necessary to maintain the track more carefully at more frequent intervals; furthermore, in Italy the general maintenance method had to be altered : the track is now levelled up

every year, whereas the general overhaul only takes place every 4 years instead of 2 years formerly.

The Railways also have found that, generally speaking, the introduction of high-speed railcars has not appreciably reduced the maintenance costs. However, the Belgian National Rys. Co. thinks that a saving should result from the replacement of steam trains by faster triple railcars.

has not changed in any way since the trains were speeded up.

We will not recall the characteristics of the most modern types of track run over by the most speeded up trains, as these have already been listed, for example by M. Flament in his report to the Paris (1937) Session. We will merely give a few details about the length of rails :

—	Track in the open.		Length of rails in tunnels.	Formation of the rails.
	Standard length of rails.	Lengths being tested.		
Italy . . .	36 m. *(118' 1 1/4")*	72 m. *(236' 2 1/2")*		New rails in sections of 36 m. *(118' 1 1/4")*.
				Electric or thermit welding of old rails 12 or 18 m. *(39' 4 1/2"* or *59' 5/8")* long.
			90 and 108 m. (1) *(295' 3 3/8" and 354' 4")*.	18 or 36 m. *(59' 5/8"* or *118' 1 1/4")* long rails welded together.
France . .	24 m. (2) (78' 9") maximum.	36 m. (3) *(118' 1 1/4")* with bevelled joint.		New rails in 24-m. *(78' 9")* sections or old rails cropped and welded together.

Several Administrations (Belgian National Rys. Co. and Italian State Rys.) insist on the importance of the transverse levelling of the track in the case of lines run over at very high speeds.

No bridge or other structure has had to be strengthened owing to speeded up services. The French National Rys. Co. reports that in its opinion the most intense period of vibration on bridges is due to speeds lying between 60 and 80 km. (37 and 50 miles) an hour. In actual fact, the cost of bridge maintenance

2. Special points in the track. Switches and crossings.

There is no doubt that the special points requiring speed restrictions are the greatest obstacles to very high speeds.

It is absolutely impossible to do away with all such points before speeding up the services; in fact they cannot be eliminated completely, but each Railway has drawn up a programme for reducing the number, which will constitute a definite step forward.

Amongst them switches taken facing,

(1) 200 m. (220 yds) and over from the portals.

(2) 36 m. (118' 1 1/4") in Algeria.

(3) 138 m. (452' 9") on a metal bridge in Algeria.

especially when running onto the branch line, are doubtless the most important.

The Belgian and French National Rys. Cos. have given us particulars of their tangent 5 crossings (to be exact, 5.5 in the case of the Belgian Rys.), which, by means of a slight cant obtained by notching the sleepers, allows of a speed of 120 km. (75 miles) an hour on the turnout.

Table E gives the characteristics of these switches and crossings.

The corresponding switches and crossings have a length of about 60 m. (exactly 62.68 = 250' 7 3/4" at the Signal box No. 1 at Longueau, France); the spring tongues are never shorter than 14 m. (45' 11"). The monoblock crossings are made of cast manganese steel. The gauge remains constant throughout the switch and crossing; it is 1.435 m. (4' 8 1/2") on those designed by the Northern Area, and 1.445 m. *(4' 8 29/32")* on those of the Eastern Area.

3. Signals.

Generally speaking the Railways continue to improve their *signals,* especially by using day-light signals, the automatic block, cab signalling equipment, etc., and to improve their regulations for a great many reasons of a general nature, not merely on account of the speeding up of the services.

In principle the same signals and regulations apply to all the services, even the fastest. In France, however, a special signal, the *half-moon,* has been introduced which only applies to railcars and means that they must slow down in certain sections; these are sections where the ordinary train speeds are lower than those of the railcars. At Tergnier Station, for example, the French National Rys. have fitted half-moon signals for 130 km. (81 miles) an hour, which only apply to the fastest railcars, as the steam trains do not exceed this speed.

The Belgian National Rys. have displaced the distant signals on lines where the train speeds exceed 100 km. (62 miles) an hour. The distance between the distant signal and the home signal has been increased to 1 000 m. (1 093 yds), and on gradients this distance is increased or reduced by 30 m. (33 yds) per 1 in 1 000 above 1 in 200 (average cost 3 700 fr. per km. (5 955 fr. per mile) of single track — Belgian currency).

No Management has introduced a *predistant* (« préavertissement ») signal as yet. The French Rys. however will install such signals on the Creil-St. Denis section where the traffic is particularly heavy.

No Railway has yet introduced *automatic train control.*

(C) Safety problems raised by high train speeds.

The French Rys. are now using a series of devices invented and designed by one of their Engineers, Mr. MAUZIN, which make it possible on the one hand to study the mechanical phenomena which may develop on any railway vehicle when running at speed, and on the other hand ascertain by measurements the condition of the track on which the vehicle is running.

The dynamic investigation of the vehicle includes essentially the measuring of the displacements, stresses, and accelerations, as well as recording all these different factors.

The stresses are determined by means of piezo-electric quartz.

The principle is as follows: When a force is exerted on a piece of quartz, quantities of electricity of opposite signs are developed on the two opposite sides of the crystal. These are collected on a three-electrode valve of very high grid-filament resistance. The measurement of the stress is transmitted by means of a piston which distributes evenly the force exerted over the whole surface of the quartz. The piston-quartz unit forms a cell which is made air-tight and placed in the

TABLE E.

Characteristics of turnouts that can be passed over at 120 km. (*75 miles*) an hour running onto the branch line.

Administrations.		Switch angle at the toe.	Crossing angle.	Layout of branch track R = radius of curve: from the toe to the heel of the tongue.	Layout of branch track R = radius of curve: from the switch toe to the crossing.	Layout of branch track R = radius of curve: in the crossing.	Length of switch and crossing.	Lead of crossing.	Constant gauge throughout the switch and crossing.	Conditions under which the turnout can be run over.
Belgian National Rys. Co.		30'	tan 0.055	R = 2 000 m. *(100 chains).* — 1 161 m. *(58 ch.)* from toe to contact of heads.	R= 1 161 m. *(58 ch.)*	R= 1 161 m. *(58 ch.)*	57.833 m. *(189 ft. 8 5/8 in.)*	8.75 m. *(28 ft. 8 1/2 in.)*	1.435 m. *(4 ft. 8 1/2 in.)*	Without superelevation, 90 km. *(56 les)* p.h. With superelevation, 120 km. *(75 miles)* p.h.
French National Rys. Co.	*Eastern Area.* Simple turnoff . . .	30'	tan 0.05	R = 2 000 m. *(100 ch.)* up to separation of heads.	R= 1 300 m. *(65 ch.)*	R= 1 300 m. *(65 ch.)*	58 m. *(190 ft. 3 1/2 in.)*	8.20 m. *(26 ft. 10 7/8 in.)*	1.445 m. *(4 ft. 8 29/32 in.)*	Without superelevation, 900 km. *(56 miles)* p.h. With superelevation, 100 to 120 km. *(62 to 75 miles)* p.h. At Chalindrey, 110 km. *(68 miles)* p.h. allowed running onto the branch.
	Symmetrical double-points.	15'	tan 0.05	R = 4 000 m. *(200 ch.)* up to separation of heads.	R= 2 600 m. *(130 ch.)*	R= 2 600 m. *(130 ch.)*				120 km. *(75 miles)* p.h.
	Northern Area. Simple turnoff with parabolic layout.	45'	tan 0.05	Cubic parabola of radius varying from ∞ to 810 m. *(40 1/2 ch.)*		R= 1 300 m. *(65 ch.)*	62.68 m. *(205 ft. 7 3/4 in.)*	8.20 m. *(26 ft. 10 7/8 in.)*	1.435 m. *(4 ft. 8 1/2 in.)*	120 km. *(75 miles)* p.h. (Example : Near signal box No. 1, at Longueau.)
	Northern Area. Simple turnoff . . .	25'	tan 0.05	R = 1 020 m. = *(51 ch.)*		straight.	53.50 m. *(175 ft. 6 1/4 in.)*	8.0 m. *(26 ft. 3 in.)*	1.435 m. *(4 ft. 8 1/2 in.)*	Without superelevation, 90 km. *(56 les)* p.h. With superelevation, 100 to 120 km. *(62 to 75 miles)* p.h.
	Symmetrical double-points.	12.5'	tan 0.05	R = 2 040 m. = *(102 ch).*		straight.				120 km. *(75 miles)* p.h.

New 2D2 (4-8-4) electric locomotive No. 713, French National Rys. Co. (South-Western Area).

vehicle, wherever the stress is to be measured.

The measurement of the accelerations depends on the same principle as that of the stresses.

The general method of investigation to study a vehicle chosen from a series of similar vehicles is as follows :

First of all the vehicle of the class with the highest stresses is selected.

To do this the French Railways have various apparatus placed along the track and recording the tranverse and vertical movements of the rails during the passage of the different vehicles. From the records of the transverse movement of the rails it is easy to find which vehicle exerts the greatest stresses, and in addition which pair of wheels on the vehicle exerts the largest stresses.

This vehicle is then fitted up with the different apparatus intended to measure the quantities which may be of interest :

Transverse and vertical forces exerted by a pair of wheels on the track;

Lateral movements of the wheels in relation to the rails;

Rolling accelerations of the body;

Hunting accelerations of the body;

Relative movements between different parts of the vehicles, if desired; etc.

The records are then taken, either with the vehicle itself, if it is a power unit, or with a train including the vehicle to be tested, the recording vehi-

2 000-h.p. BB (4-4) type locomotive hauling a local passenger train, French National Rys. Co. (Western Area).

cle, and the vehicle for ascertaining the state of the track.

During the different running tests, records relating to the vehicle being tested and to the condition of the track are obtained on one and the same band. The factors relating to the vehicle being tested can then be modified as required by the investigation of the problem raised.

Such measurements are made systematically by the French Railways before any new type of stock for very high speeds is put into service, or when a series of vehicles has been running badly and abnormally.

In particular, before deciding to run the triple Franco-Belge type railcars at 150 km. (93 miles) an hour, systematic

measurements were taken according to the methods described above, on a multiple-unit railcar which was going into the shops for heavy repairs, i.e. with maximum wear of all the main parts. It was only after this investigation, which gave satisfactory results and showed that the margin of safety could be taken as amply sufficient, that the triplet was stated to be suitable for speeds of 150 km. an hour on the track over which it had run during the said tests.

To make the value of this test method more apparent, we will give two examples of its use, one being a very simple application to find the cause of a defect in an *Atlantic* type steam locomotive, the other, much more complicated, to find the cause of a defect in a type BB electric locomotive.

1. *Test made with a P.L.M. 4-4-2 engine.*

The problem was as follows:

Check, and if need be modify, an engine so that at 140 km. (87 miles) an hour the lateral stresses will be equal to or less than those on a 4-6-2 engine.

Although the problem is stated simply, there are certain difficulties in its determination, owing to the fact that the disturbing influence of a pair of wheels on the track depends on the vertical load on this pair of wheels and its position in the frame of the engine.

According to one theory the resistance of the track only depends on the load supported, the transverse strength of the track being mainly due to the friction between the sleepers and the ballast. On the other hand, the effect on the track due to a certain stress is not the same if the pair of wheels is at the leading end, in the middle or at the trailing end of the engine, the track obviously not being maintained in the same way in the three positions of the pair of wheels considered.

The lateral stresses exerted by the four wheels of the bogie and the first and last coupled pair of wheels on the two locomotives, 4-4-2 and 4-6-2, were recorded.

From the very onset, it was seen that the problem was simplified by the fact that there appeared to be any appreciable difference only between the third pair of wheels (first coupled pair) of the two locomotives in question.

It was found that the lateral stresses exerted by the third pair of wheels of the 4-4-2 engine (which were greater than those of the 4-6-2) were exerted periodically, the period being equal to a revolution of the wheel.

The defective balancing of the first coupled pair of wheels of the 4-4-2 locomotives resulted in the distance between the flanges increasing at each revolution of the wheel and consequently the stress on the track increased considerably.

These tests finally showed the need for balancing the alternating masses of the first coupled pair of wheels.

When considering a particular point of view, it was found that before being altered, the first coupled pair of wheels of the 4-4-2 engines exerted a force of 6 tons. After alteration, the first coupled pair of wheels only exerted a force of 2 tons at the same point while the 4-6-2 engines, at 120 km. (75 miles) an hour also at the same point, exerted a force of 2.5 tons on the first coupled pair of wheels.

The problem was therefore solved by balancing the first coupled pair of wheels.

2. *Tests made with the BB electric locomotives.*

The tests made on the BB locomotives can be summed up as follows:

When certain lines were originally electrified, the P.-O. and Midi Systems were led to study the behaviour of the BB locomotives on the track and the stresses produced.

Out of a stock of 160 engines, two were selected as having given higher transverse movements of the rail than the others. These two engines were studied and it was found

that they had a constructional defect (not true to design).

By continuously taking records of the transverse stresses exerted by these two locomotives, it was found that abnormal stresses were set up only occasionally.

It was then necessary to find out under what conditions the defect led to abnormal transverse stresses.

Guided by experience obtained in current service, artifical warps were made on straight sections of track. Abnormal lateral stresses of varying intensity were recorded on these engines when running through these artificial warps.

Finally, after precise experiments, it was found possible to ascertain exactly the part played by the hygrometrical condition of the rail, in other words by the coefficient of friction between wheels and rails, on the hunting of the engines.

From these tests the conclusion drawn and subsequently proved was that for the track to be displaced laterally to any marked extent it was necessary to have an engine not true to design, a track in a loosened condition, a marked warp in the track, and a high coefficient of friction between the wheels and rails.

In view of the number of different factors involved, it can be appreciated how difficult it was to study this question.

Though the problem could be considered as cleared up, it was desired to diminish if possible the fatigue to which the track was subjected, and whilst keeping the same speed limits for some of these B B electric locomotives, increase the speed limit of certain other locomotives.

The study of this question led to the design of a coupling with initial centering, which is fitted between the bogies.

The quartz equipment made it possible to determine the best adjustment of the centering of the coupling between bogies, an adjustment which is practically impossible if based merely on the impression gathered on the locomotive as regards the riding.

A locomotive which exerted before this coupling was fitted, at a speed of 105 km. (65 miles) an hour at each half-period of hunting, i.e. about every 8.50 m. (28'), an alternating stress on each rail of about 8 tons, after it was fitted exerted a stress of less than 4 tons.

The investigations reported above are an incontestable improvement in railway technique, as they make it possible to eliminate the causes of mishaps, and to increase the speed limits of the trains while decreasing the fatigue to which the track is subjected.

In other countries investigations are carried out with different devices, and according to different methods; in Italy, for example, stress measuring apparatus are used, based on the properties of graphite.

* * *

CHAPTER III.

Railcars.

(A) Chief services covered by railcars.

It is necessary to consider separately railcars used for fast services at speeds exceeding 120 km. (75 miles) an hour, and the railcars for the other services whose maximum speed is usually 120 km. an hour or less.

(1) Railcars for high-speed services.

These railcars vary in construction and arrangement according to whether they are intended for very high speeds on the main lines [maximum speed 140 km. (87 miles) an hour — 1st and 2nd class compartments], or for fairly long distances over cross country lines [maximum speed 120 km. (75 miles) an hour — 2nd and 3rd-class compartments].

a) **Belgium.**

The Belgian high-speed railcars are triple units with 2nd and 3rd-class compartments, of 730 to 900 H.P., weighing about 150 t. (147 1/2 Engl. tons), and were put into service in 1936.

The following table gives a few particulars about the services worked :

—	Distance in km. *(in miles).*	Max. gradient.	Journey time, in minutes.	Overall speed km./h. *(m.p.h.).*
Brussels (Midi)-Ghent (St. Pierre).	53 *(32.9)*	1 in 200.	28	121 *(75.2)*
Brussels (Midi)-Ostend (Quay).	116 *(72.1)*	1 in 200.	64	109 *(67.7)*
Brussels (Midi)-Charleroi . .	56 *(34.8)*	1 in 87.	40	84 *(52.2)*
Brussels (Midi)-Mons	61 *(37.9)*	1 in 200.	37	99 *(61.5)*
Brussels (Nord)-Namur . . .	62 *(38.5)*	1 in 63.	43	87 *(54.1)*
Brussels (Midi)-Liége. . . .	100 *(62.1)*	1 in 200.	69	87 *(54.1)*

Eight triple railcars are worked by one, two or three crews according to a roster which includes 5 workings :

	km.	*(miles)*
Service 1 — Single crew (and weekly maintenance)	326	*(202.5)*
Service 2 — two crews	790	*(490.9)*
Service 3 — two crews	699	*(434.4)*
Service 4 — two crews	828	*(514.5)*
Service 5 — three crews	787	*(489.0)*
	3 430	*(2 131.3)*

Average $\frac{3430}{5}$ = 686 km. = *426.3 miles.*

A sixth railcar with staff stands in reserve.

The last two railcars are spare or undergoing repairs.

The chief characteristics of the 8 Belgian diesel-electric triple railcars with 4 four-wheeled bogies, two being motor bogies, are :

Type 653 *La Brugeoise-Maybach* — 3 railcars, two 410 H.P. engines, each of which since it was first put into service up to the 1/10/1938 has run an average of 290 665 km. (180 614 miles);

Type 654 *Baume-Marpent-S.E.M.* — 3 railcars, two 365-H.P. engines each of which since it was first put into service up to the 1/10/38 has run an average of 255 982 km. (159 063 miles);

Type 655 *Baume-Marpent-Mercedes-Benz* — 1 railcar, two 450-H.P. engines; mileage up to 1/10/38 : 81 000 km. (50 330 miles).

Type 656 *Baume-Marpent-Frichs* — 1 railcar, two 400-H.P. engines, mileage up to 1/10/38 : 111 091 km. (69 030 miles).

Type.	Length.	Tare empty, Metr. *(Engl.)* tons.	Tare in working order Metr. *(Engl.)* tons.	Weight in working order per seat kgr.*(lb.).*	H.P. per ton in working order.	Capacity. Seated.	Capacity. Standing.	Capacity. Total.	Max. speed. km./h. *(m.p.h.).*
653	59.90 m. *(196' 6 1/2").*	126.4 *(124.4)*	130.4 *(128.3)*	569 *(1 254)*	6.3	229	40	269	150 *(93.2)*
654		133.0 *(130.9)*	138.0 *(135.8)*	602 *(1 327)*	5.3				135 *(83.9)*
655		130.0 *(127.9)*	135.0 *(132.9)*	589 *(1 298)*	6.7				150 *(93.2)*
656		132.0 *(129.9)*	137.0 *(134.8)*	598 *(1 318)*	5.8				140 *(87.0)*

La Brugeois-Maybach diesel-electric railcar with two 410-h.p. engines, Belgian National Rys. Co.

Franco-Belge quadruple railcar about to enter the « Gare du Nord » (Paris).

b) **France.**

There are five types of French high-speed railcars, as follows :

— FRANCO-BELGE triplets, so-called T.A.R. (train automoteur rapide);
— BUGATTI 800-H.P. single railcars which can haul a special trailer;
— BUGATTI 400-H.P. single railcars;
— BUGATTI 800-H.P. triple railcars;
— RENAULT 600-H.P. double railcars.

The following table shows the rostered daily mileage for each type :

Railcars.	Centre.	Daily mileage (according to the 1938/1939 winter workings) maximum km. *(miles)*	average km. *(miles)*	minimum km. *(miles)*
T.A.R.	La Chapelle.	362 *(224.9)*	362 *(224.9)*	362 *(224.9)*
	Fives.	526 *(326.8)*	526 *(326.8)*	526 *(326.8)*
Bugatti, triple	Strasbourg.	1 006 *(625.1)*	1 006 *(625.1)*	1 006 *(625.1)*
Bugatti, 800 H.P.	Batignolles.	456 *(283.4)*	456 *(283.4)*	456 *(283.4)*
	Nantes.	511 *(317.5)*	461 *(286.5)*	411 *(255.5)*
Bugatti, extra-long	Venissieux.	445 *(276.5)*	323 *(200.7)*	220 *(136.7)*
	Nantes.	644 *(400.2)*	334 *(207.6)*	142 *(88.2)*
Renault, A.B.V.	Lyons.	754 *(468.5)*	575 *(357.3)*	468 *(290.8)*
	Rouen.	496 *(308.2)*	408 *(253.5)*	320 *(198.8)*

The following table gives the average daily mileage by each railcar of this stock (from the working results of the first half year 1938).

Railcars.	Centre.	Average daily mileage per railcar km. *(miles)*
T.A.R.	La Chapelle.	464 *(288.3)*
	Fives.	292 *(181.4)*
Bugatti, 800 H.P.	Batignolles.	201 *(124.9)*
	Nantes.	186 *(115.6)* (2nd half year).
Bugatti, extra-long.	Venissieux.	197 *(122.4)*
	Nantes.	201 *(124.9)*
Renault, A.B.V.	Lyons.	294 *(182.7)*
	Rouen.	251 *(156.0)*

Franco-Belge type triplets.

The Northern Area operates 10 triplets (2 of the 1934 type and 8 of the 1936 type), the leading characteristics of which have often been stated.

These sets, designed for a maximum speed of 150 km. (93 miles) an hour, are restricted to a maximum of 140 km. (87 miles) an hour in service.

For the 1934 type sets, the maximum speeds allowed are :

— 132 km. (82 miles) an hour on 1 in 330 gradients;
— 93 km. (57.8 miles) an hour on 1 in 110 gradients.

The use of the electro-magnetic brake and the compressed air brake makes an emergency stop possible in 550 m. (600 yds) and 24 seconds, from a speed of 140 km. (87 miles) an hour on a 1 in 200 down gradient.

The Franco-Belge triplets were put into service in July 1934, between Paris and Lille.

Since then additional services have been created between Paris and Liége, and between Paris and Brussels. At the present time, there are two services there and back between Paris-Lille-Tourcoing and one service there and back between Paris and Nancy.

The 258 km. (160.3 miles) between Paris and Lille are covered in 2 hours 25 minutes, i.e. at an average speed of 107 km. (66.5 miles) an hour.

The T.A.R. sets consist of 1st and 2nd class compartments, and passengers do not have to pay any supplement for travelling in them.

Bugatti 800-h.p. single railcars.

The Western Area operates 8 railcars of this type. Their speed in service is limited to 140 km. (87 miles) an hour, but they can easily exceed 160 km. (100 miles) an hour (1) on easy lines.

Thanks to their high specific power, they are able to haul a special Bugatti trailer, which increases their seating capacity from 60 to 102.

The railcar by itself starts and accelerates most satisfactorily on the level; speeds of 120 and 140 km. (75 and 87 miles) an hour are reached in 1 minute 50 seconds and 2 minutes 20 seconds respectively.

These railcars were put into service in May 1934, between Paris and Havre, in order to improve the afternoon services from Havre to Paris.

The number of additional high-speed services between these two cities, which was increased to 2 in October 1934 and to 6 in May 1936, had to be reduced to one in October 1938 in order to reduce expenditure.

The 228 km. (141.7 miles) between Paris and Havre are covered in 1 hour 58 minutes, i.e. at an average speed of 116 km. (72.1 miles) an hour, when the railcars do not stop at Rouen, and in 2 hours, i.e. at 114 km. (70.8 miles) an hour when they do.

These Bugatti railcars also are used for other high-speed services, both permanent and seasonal, for example :

Paris-Trouville-Dives-Cabourg,
Paris-Dieppe,
Dieppe-Nantes.

(1) During the trials they reached a speed 190 km. (118.1 miles) an hour.

Bugatti 400-h.p. single railcars.

The Eastern, Western and South-Eastern Areas have in service a total of 67 Bugatti 400-h.p. railcars, of three types : short, long, extra-long.

Most of these railcars can run at 140 km. (87 miles) an hour.

The extra-long railcars can reach on the level a speed of 120 km. (75 miles) an hour in 2 minutes 50 seconds, and 140 km. (87 miles) an hour in 4 minutes 20 seconds. They can also climb 1 in 40 gradients at a speed of 75 km. (46.6 miles) an hour.

Amongst the high-speed services worked by these railcars, we must mention :

Nice-Marseilles,
Lyons-Geneva,
Lyons-Strasbourg,
Paris-Clermont-Vichy.

Bugatti 800-h.p. triple railcars.

The Eastern and Western Areas possess 5 (2 of which have still to be delivered) and 2 triple railcars respectively.

These cars, particularly well arranged interiorly, can run at 140 km. (87 miles) an hour. They reach a speed of 125 km. (77.7 miles) an hour in 3 minutes 20 seconds, and can climb 1 in 66 gradients at 60 km. (37.3 miles) an hour.

Since the 2nd October 1938, the railcars of the Strasbourg Sub-Division work a service between Paris and Strasbourg there and back in 4 hours 25 minutes, i.e. at an average speed of 114 km. (70.8 miles) an hour. An additional service there and back between Paris and Nancy will shortly be introduced with these triplets.

These railcars have only 1st and 2nd class compartments, and a small « speed » supplement is charged.

The two railcars of the Batignolles centre are mainly used for the transatlantic services between Paris and Havre, and Paris and Cherbourg.

Renault A.B.V. twin railcars.

The French Rys. altogether own 13

800-H.P. BUGATTI railcar and trailer on the Paris-Havre line.

BUGATTI triplet.

such railcars. Their capacity varies from 82 to 114 seats and a luggage compartment of 6 to 10 m² (64 1/2 to 107 1/2 sq. ft.); there are kitchens on about a dozen of them.

The performances of those railcars designed for a speed of 120 km. (75 miles) per hour are as follows :

(1) On the level — 122 km. (75.8 miles) p. h.;
On a 1 in 200 gradient — 113 km. (70.2 miles) p. h.;
On a 1 in 100 gradient — 87 km. (54.1 miles) p. h.;
On a 1 in 45.5 gradient — 52 km. (32.3 miles) p. h.

(2) On the level a speed of 100 km. (62 miles) an hour is reached in 3 minutes.

(3) On a 1 in 200 down gradient, using the compressed air brake alone, it is possible to stop in 480 m. (525 yds) and 27 seconds from a speed of 122 km. (75.8 miles) an hour.

These cars are normally intended for use in semi-express services. They have also been used for high-speed services, whilst awaiting the delivery of the special stock for such services. For example, they were used between Paris and Strasbourg before the Bugatti triplets were put into service; they made the Paris-Strasbourg run in 4 hours 25 minutes, i.e. at an average speed of 114 km. (70.8 miles) an hour.

They were however intended especially for semi-express services on the cross country lines (Lyons-Strasbourg, Bordeaux-Clermont, Lyons-Clermont).

The Clermont-Lyons run via Tarare (217 km. = 134.8 miles) takes 3 hours 12 minutes in spite of 6 km. (3.7 miles) of 1 in 50 gradients, 20 km. (12.4 miles) with an average 1 in 143 gradient, and 7 intermediate stops, which take up 9 minutes altogether; the overall speed is 68 km. (42.3 miles) an hour.

These cars are used by 1st, 2nd and 3rd-class passengers, but the 3rd-class passengers have to pay a supplement.

c) **Netherlands.**

The Netherlands Rys. have electrified their main lines carrying heavy traffic and intend to extend this partial electrification of their system. The use of railcars, however, is not reduced thereby, as it is not economical to electrify lines with light traffic.

The use of railcars has made it possible to extend to a certain number of other lines the improved services provided by electrification, i.e. increased train frequency and accelerated services.

It should be recalled that in 1938 the Netherlands Railways completely modified their working by making general the « connecting point system » which had been partly tried since 1934. There is a service of through trains at regular intervals every 2 hours as a rule, or every hour on certain lines, and even every half hour at rush hours; this means that the frequency has been practically doubled in certain cases, whilst the journey times have been reduced by about one third. At the same time 148 stations have been closed to passenger traffic, and certain small lines have been closed down altogether. The short-distance traffic and services to small places have been given up almost entirely to road transport.

The problem raised by this new method of operating is a particularly delicate one, as the increased speed has to coincide with perfect regularity of service; there are in fact a great many connections at the junction points and some of them mean not only the passengers changing over from one train to another, but also coupling up different sets coming from different places which go on to another important centre as one train.

Very fast timings, very close interdependence of the different services, are the two elements of the operating problem which diesel-electric triplets — either by themselves or in conjunction

with other methods of traction — have solved in Holland. It may be added that the great number of trains involves a very rapid turn-round of the stock, and the effects of any sudden throwing out of service are very serious; the experience obtained with these diesel-electric sets is therefore of particular value. The radical alteration of the timetables thereby made possible, together with the electrification of the lines, has led to a considerable increase in the number of passengers carried.

The Netherlands Railways consider that sets of 3 coaches or more, taking 150 to 300 passengers, equipped with automatic couplings so that 2 to 4 sets can be coupled up together, are the most suitable for present-day requirements of high-speed passenger services.

The triplets have accelerations of :

90 km. (56 miles) an hour in 52 seconds;
120 km. (75 miles) an hour in 90 seconds; and
140 km. (87 miles) an hour in 150 seconds.

This acceleration is currently utilised in service.

The daily mileage for the triplets is :

maximum . . . 1 082 km. (672 miles);
average. . . . 655 km. (407 miles);
minimum . . . 201 km. (125 miles).

The average daily mileage per railcar of the whole stock is 401 km. (249 miles) for the triplets.

The proportion of reserve triplets for regular services is 5 %, and 10 % for the supplementary services.

d) **Italy**

For high-speed services [Max. speed 130-140 km. (81 to 87 miles) an hour], the railcars must have a power of at least 9 to 10 H.P. per ton of tare weight. The railcars in use at present work the following typical services :

Turin-Leghorn : 351 km. (218.1 miles), 40 km. (25 miles) being mountain lines with gradients reaching 1 in 63. Journey time, 3 hours 47 minutes with 2 intermediate stops.

Milan-Ventimiglia : 301 km. (187 miles), 40 km. (25 miles) being mountain lines, with gradients reaching 1 in 63. Journey time, 3 hours 59 minutes with 8 intermediate stops.

Turin-Milan : 153 km. (95.1 miles) on the level. Journey time, 1 hour 32 minutes with one stop.

The chief characteristics of the Fiat triplets and Breda high-speed units built during recent years are as follows :

Fiat. — 4 bogies, the two outer ones being motor bogies. Two 12-cylinder Vee-type 4-stroke 450-H.P. Fiat-diesel engines, with Fiat 4-speed mechanical drive.

These cars are very well fitted out, and are equipped with air conditioning, and kitchen, the current for all the auxiliary services being supplied by a diesel-generator set. Speed 160 km. (100 miles) an hour.

Breda. — Breda Aln 50. Two AEC Breda 115-H.P. engines, Wilson gearbox, hydraulic transmission. Weight empty, in running order, 24 t. (23.6 Engl. tons). Speed 140 km. (87 miles) an hour.

e) **Rumania.**

The Rumanian Railways have on trial 3 streamlined twin railcars which can also run as single units. — Maximum speed : 110 km. (68.3 miles) an hour. Commercial speed (on a 260-km. = 161.6 miles run) : 87.6 km. (54.4 miles) an hour.

They are 2nd-class vehicles with buffet and luggage compartment. Average daily distance covered : 300 km. (186 miles).

The chief characteristics of these railcars (which can run with 1 or 2 special trailers with automatic couplings between them) are :

As usually composed (2 cars coupled together), there are 136 seats.

Fiat ALn type railcar with two 145-h.p. diesel engines.

Breda ALn 56 type railcar with two 130-h.p. diesel engines.

Weight in service 84 t. (82.7 Engl. tons). Total length over buffers 46.73 m. (153' 3 3/4").

Each coach is carried on two bogies, one being a power bogie, and has one driving compartment. — 6-cylinder Vee-type Ganz-Jendrassyk diesel engine developing 220 H.P. at 1 250 r.p.m.

Mechanical drive with friction clutch, one reverser, 5 speeds, two pairs of wheels driven by cardan shafts.

Maximum speed 110 km. (68.3 miles) an hour.

Body of special steel, heating by engine cooling water, cooling by freon plant.

(2) Railcars other than for high-speed services.

The French Railways group such railcars into four categories, A, B, B' and C, namely :

1. *Category A.* — Single cars with room for some 100 passengers seated or standing, of such power that they are able to haul about 40 tons trailing load (passenger coach, special trailer or goods wagons) and reach a speed of at least 100 km. (62 miles) an hour on the level, and 75 km. (46.6 miles) an hour up 1 in 100 gradients.

There railcars, the typical example of which is the *Standard* railcar, will have to be fitted with ordinary draw and buffing gear so that they can haul any sort of railway vehicle for fast or slow traffic).

With such a car it is possible :

— to increase economically the carrying capacity of railcar services;

— to draw up programmes involving the cancellation of a relatively large number of local passenger trains, even when special coaches or parcels wagons have to be worked by such trains;

— to keep to the programme drawn up for the utilisation of railcars when such vehicles have to be replaced occasionally by steam trains.

2. *Category B.* — Single railcars with room for about 100 passengers seated or standing, running as single units or as twins, but not equipped to haul other vehicles as trailers.

These cars must be able to run at 100 km. (62 miles) an hour on the level and 75 km. (46.6 miles) an hour up 1 in 100 gradients at least. The horse-power per ton empty is about 10 to 12.

This second type of railcar (*Renault* A.B.J. 320-H.P. *de Dietrich, Micheline)* has an advantage over category A in that it can run at the same speeds as a single unit or as twins, and consequently is preferable for certain services with difficult timings (supplementary services in particular). On the other hand it has two drawbacks :

— It is more costly than the standard railcar as soon as it has to be run as a twin unit frequently;

— It cannot haul full-wagon loads of parcels traffic, which limits its use on lines where the local passenger trains also cover a relatively large mail or parcels traffic.

3. *Category B'.* — These are railcars derived from the previous type, and specially intended to cover services where, with the same total carrying capacity of some hundred passengers, it is possible to reduce the power and the cost, as the performance need not be so good (replacement services or supplementary services on easy lines).

With these cars a speed of 90 km. (56 miles) an hour on the level and 60 km. (37.3 miles) an hour up 1 in 100 gradients is sufficient. These relatively moderate requirements, in conjunction with a simpler and lighter construction, enable the power required to be considerably reduced, and in consequence the total cost.

4. *Category C.* — For certain local or semi-express services, the traffic may be consistently heavy enough to make it necessary to normally use two railcars of type B coupled together. In this case it is

Standard railcar with trailer, on the Amiens-Rouen line.

320-h.p. and 500-h.p. de Dietrich railcars at the Besançon depot.

more economical to provide double railcars (example, *Renault* A B V).

This solution, which from the technical point of view resembles that of large-capacity railcars for express services, is however exceptional. It is also possible at times to use the same railcars for such services with very heavy traffic and for certain express services over long or medium distances.

The very light four-wheeled railcars of small capacity must be put into a separate class, which we will call *Category D.*

Let us take up again each of these categories as regards France : —

1. *Category A :*

— *Standard* railcars about 60 of which are in service at the Saint-Dié, Cambrai and Narbonne centres; 600-H.P. engines. Usually haul 1 or 2 vehicles and even 3 (if their total weight is less than 45 tons) or 2 standard trailers;

— The 600-H.P. *Decauville* railcars of the Grenoble centre (9 in service and 10 under construction);

— The 500-H.P. *de Dietrich* railcars of the Besançon centre (2 in service and 4 now being delivered);

— the 500-H.P. *Renault A.D.P.* railcars of the Caen centre (7 railcars) and Aurillac centre (8 railcars now being delivered);

— The 600-H.P. *Renault ADX*[2] railcars, 21 of which are under construction;

— The *Berliet* parcels motor vans, of the South Eastern Area, which can haul 5 vehicles (max. 60 tons) or on certain sections 75 tons.

2. *Category B :*

— The *Renault A.B.J.* railcars of the Rouen, Lyons-Vaise, Bordeaux and Nancy centres, and the *Renault V.H.* cars (*A.B.J.* and *V.H.* railcars in service on the French National Rys. Co.'s lines);

— The 320-H.P. *de Dietrich* railcars of the Rennes, Besançon and Mulhouse centres;

— The *Michelin* 56 and 96-seater railcars of the Besançon, Clermon, Carmaux and Brittany centres;

— The *Berliet* railcars of the Roanne centre;

— The *A.D.N.* railcars of the Châlon-sur-Saône centre.

3. *Category B' :*

— The *Renault A.E.K.* railcars of the Noisy-le-Sec and Rouen centres.

4. *Category C :*

— The *Renault V.H.D.* and *A.B.V.* twin railcars of the Rouen, Rennes, and Lyons-Vaise centres.

The theoretical daily mileage based on the working programmes of these railcars is shown in the following table :

Railcars.	Centres.	Daily mileage (according to the 1938-1939 winter workings).					
		maximum		average		minimum	
		km.	*miles.*	km.	*miles.*	km.	*miles.*
Standard	Cambrai	561	*349*	361	*224*	230	*143*
	Saint-Dié	507	*315*	382	*237*	160	*100*
Decauville, 600 H.P.	Grenoble	735	*457*	476	*296*	189	*117*
Renault A.B.J.	Lyons	524	*326*	408	*254*	307	*191*
	Rouen	615	*382*	326	*203*	61	*38*
	Nancy	626	*389*	420	*261*	180	*112*

Table continued of following page.

Railcars.	Centres.	Daily mileage					
		maximum		average		minimum	
		according to the 1938-1939 winter workings).					
		km.	*miles.*	km.	*miles.*	km.	*miles.*
de Dietrich, 320 H.P.	Rennes	365	*227*	320	*199*	289	*180*
	Besançon	590	*367*	415	*258*	242	*150*
	Mulhouse	483	*300*	386	*240*	289	*180*
Michelin, 56-seater	Besançon	462	*287*	362	*225*	262	*163*
Michelin, 96-seater	Troyes	462	*287*	314	*195*	110	*68*
	Saint-Brieuc 56-seater.	637	*396*	453	*281*	279	*173*
	Saint-Brieuc 96-seater	524	*326*	524	*326*	524	*326*
Berliet	Roanne.	634	*394*	395	*245*	183	*114*
A.D.N.	Châlon.	588	*365*	348	*216*	177	*110*

The opposite table gives the average daily mileage per railcar (according to the working results for the 1st half of 1938).

Belgium.

The Belgian National Rys. Co., in addition to its 8 diesel-electric triple sets, has :

— 5 steam railcars of various types;
— 21 bogie railcars } Diesel-mechani-
— 6 four-wheeled railcars } cal of 8 different types.
— 3 diesel-electric railcars of 3 types, which daily cover the following distances :

maximum	*average*	*minimum*
345 km.	264 km.	192 km.
(214 miles)	*(164 miles)*	*(119.3 miles)*

The average daily mileage of each railcar of the stock as a whole lies between 125 and 155 (200 and 250 km.).

The percentage of reserve cars is 25.

In addition, 50 four-wheeled *Brossel* railcars for secondary lines, and 24 railcars of various designs will be put into service in 1939.

Italy.

Some of the old types of railcars are the only ones able to haul trailers at re-

Railcars.	Centres.	Daily mileage.	
		km.	*miles.*
Standard.	Cambrai	227	*141*
	Saint-Dié	233	*145*
Decauville, 600 H.P.	Grenoble.	241	*150*
Renault. A.B.J.	Lyons	265	*165*
	Rouen.	310	*193*
	Nancy	268	*167*
de Dietrich, 320 H.P.	Rennes	261	*162*
	Besançon	305	*190*
	Mulhouse	259	*161*
Michelin, 56-seater.	Besançon	253	*157*
	Troyes	198	*123*
	St.-Brieuc :		
	56-seater	324	*201*
	96-seater	219	*136*
Berliet	Roanne	184	*114*
A.D.N.	Châlon	224	*139*

140 H.P. 120-seater BROSSEL bogie railcar for secondary lines, Belgian National Rys. Co.

Interior of BROSSEL 120-seater railcar.

Malaxa motorised carriage, Rumanian Railways.

duced speeds. The recent railcars were not built to do so.

The daily mileage per railcar varies from 702 to 72 km. (436 to 45 miles).

The percentage of reserve cars is 18.5.

The average daily mileage per railcar is 202 km. (125.5 miles) for the whole stock.

The chief characteristics of the railcars are as follows :

Fiat, the most usual type being the ALn 56. — 2 power bogies, 56 seats, standing room for 20, mail compartment, W.C.;

— two 80-h.p. *Fiat* diesel engines, mechanical drive; weight empty in running order 20 t. (19.7 Engl. tons); speed 110 km. (68.3 miles) an hour.

Rumania.

All the 184 railcars can haul a special trailer (with roller bearings).

Trains of 2 railcars and 2 trailers can be made up as follows :

P.U. + P.U. + Tr. + Tr.,
or P.U. + Tr. + Tr. + P.U.,
or P.U. + Tr. + P.U.+ Tr.,

the staff consisting of 2 drivers, 1 guard, 1 conductor.

The daily mileages are as follows :

	Max. km. *(miles)*	Aver. km. *(miles)*	Min. km. *(miles)*
Main lines . .	519 *(323)*	426 *(265)*	333 *(207)*
Branch lines .	460 *(286)*	250 *(155)*	30 *(19)*

The average daily mileage per railcar varies from 220 to 230 km. (137 to 143 miles) according to the type.

The percentage of reserve cars is 15.

Characteristics of the light four-wheeled railcars : 120 or 150-H.P. *Ganz* or *M.A.N.* engines; tare 24 t. (23.7 Engl. tons); maximum speed 85 km. (52.8 miles) an hour; 59 seats; welded throughout.

The Rumanian Railways have converted 99 passenger coaches by equipping them with 120 to 220-H.P. engines.

Algerian Railways.

Renault A.B.V. twin railcars — 600 H.P., carrying 107 passengers, working a regular service between Alger, Tizi and Ouzou (108 km. = 67.1 miles), and the Type 23 *Michelines,* 96 places, for the Constantine-Biskra service, have given complete satisfaction on these lines.

On the metre-gauge lines (penetration towards the south) a first regular service with *de Dietrich* railcars has just been started between Biskra and Touggourt (217 km. = 134.8 miles), where steam services come up against serious difficulties owing to the bad water supply and the long desert run (fine sand getting into the motion).

The run is made in 3 hours 8 minutes (local service saving 55 % of time on the steam train).

Characteristics of the *de Dietrich* rail motor trains :

— 1 motor van on two four-wheeled bogies, which can also be used for goods services.

— 2 *Saurer* (or *Sulzer*) diesel engines of 300 H.P., each coupled to 1 generator feeding the two electric motors mounted on each of the bogies (*Oerlikon* electrical equipment). It can run with only one motor driving. One luggage compartment, one mail compartment, and 2 driving compartments are provided; the engine room is protected against sand.

— one trailer consisting of 2 bodies on 3 four-wheeled bogies; 114 seats, 26 being 1/2nd class. A buffet-bar.

Weight of the whole set : 80 t. (78.7 Engl. tons).

Authorised speed 105 km. (65.3 miles) an hour, although nothing was done to the permanent way; the speed limit for steam locomotives is 60 km. (37.3 miles) an hour.

Performance during trials : 45 km. (28 miles) an hour reached and sustained on a 1 in 37 gradient.

Railcar stopped in 15 seconds and 200 m. (220 yds) from a speed of 90 km. (56 miles) an hour on the level.

There are two such sets in service.

The stock will be completed by two motor vans to work the goods traffic.

Similar stock is now being designed for service on the Oran—Colomb-Béchar line.

Tunisian Railways.

On the standard-gauge lines : *Renault A.B.J.* railcars, 265 to 300 H.P. Maximum daily distance covered : 490 km. (304 miles); average 392 km. (244 miles); minimum 188 km. (117 miles). Average per railcar for the whole stock : 215 km. (134 miles).

Tunis-Bizerte service, 98 km. (60.9 miles), taking 1 hour 43 minutes (compared with 2 hours 15 minutes by steam train) with 11 intermediate stops.

Tunis-Ghardimaou service, 189 km. (117.4 miles), taking 3 hours (against 3 hours 50 minutes).

Two crews per railcar.

On the metre-gauge lines, the complete programme, now partly completed, will include the following services :

Tunis-Sousse, in 2 h. 15 m., compared with 3 h. 20 m. by steam train;

Tunis-Sfax, in 3 h. 50 m., compared with 6 h. 5 m.;

Tunis-Gabès, in 5 h. 55 m., compared with 10 h. 45 m.;

Tunis-Tozeur, in 9 hours, compared with 17 h. 45 m.;

Tunis-Kaloa-Djerda, in 4 hours, compared with 7 h. 25 m. by steam train.

For these services, twelve 400-h.p. *de Dietrich* twin railcars will be required, some of which have already been delivered.

Daily mileage :

Maximum.	Average.	Minimum.	Average whole stock.
640 km.	423 km.	300 km.	250 km.
(398 miles)	*(263 m.)*	*(186 m.)*	*(155 m.)*

Chief characteristics of the railcars :

Length 29.73 m. (97' 6 1/2") — standard loading gauge; two bodies on 3 bogies, the two outer driving — two 200-h.p. engines — Weight empty 46 t. (45.3 Engl. tons) — 102 seats.

Meals are served on certain railcars. — Special care has been given to the heat insulation.

At the present time on the Tunisian Railways, the daily mileage covered by railcars is 2 357 (3 793 km.), compared with 570 miles (918 km.) by steam trains.

Indo-China and Yunnan Rys.

Single-track metre-gauge system.

— Haifong-Hanoi service : 102 km. (63.4 miles) :

3 express railcar services, taking 1 h. 55 m. and 1 h. 59 m. with 3 or 5 intermediate stops respectively (compared with 2 h. 50 m. by steam train, with 4 stops).

2 semi-express railcar services, taking 2 h. 15 m. or 2 h. 25 m., with 6 or 9 intermediate stops;

Total : 5 railcar services compared with 1 steam service in 1934.

Railcars used : 5 *Decauville* railcars with one or two 140-h.p. Saurer diesel engines; 50 seats.

— *Ho-K'eou-Yunnanfou* service (465 km. = 289 miles) :

1 railcar service twice a week, taking 12 h. 1 m. in the Yunnanfou direction with 20 stops, one stop lasting 51 minutes, and 12 h. 17 m. from Yunnanfou, with 19 stops, one of 1 h. 2 m.

Railcars used : 2 *Michelines,* 1 with 15 seats and 24-h.p. Panhard engine, and 1 with 37 seats, 46-h.p. Hispano engine.

Belgian National Light Rys. Co.

The stock of railcars works daily 39 000 tr.-km. (24 230 train-miles) compared with 118 000 tr.-km. (73 320 train-miles) for the electric motor coaches, with an average distance of 275 to 300 km. (171 to 186 miles) per railcar per day (maximum 400 km. = 250 miles).

The railcars used can haul 1 to 5 trailers according to the gradients on the line.

Running as a single unit, a railcar can sustain an overall speed of 35 km. (21.7 miles) an hour on hilly lines. With a trailer this speed falls to 28 km. (17.4 miles) an hour.

French secondary Railways.

The French secondary railways now work more than 5 800 km. (3 600 miles) of line served by railcars.

On the 1st July 1938, the total stock of railcars numbered 258 units, the power of which varied from 135 to 150 h.p., with a few reaching 300 h.p. The power is 10 h.p. per ton and more than 12 h.p. in the case of two *Billiard* railcars with a 250-h.p. C.L.M. diesel engine. Most of these railcars can haul either an ordinary coach or a specially designed vehicle.

The results obtained have been thoroughly satisfactory :

In 1937 the railcars ran 12 000 000 km. (7 457 000 miles) at an average speed of between 35 and 40 km. (21.7 and 25 miles) an hour [compared with 20 km. (12.5 miles) an hour for the former steam trains]; the maximum speed reached 70 km. (43.5 miles) an hour and more, whereas with steam traction it only reached 50 km. (31 miles).

In 1937 the total cost varied between

Tunis Station. — RENAULT railcars, and DE DIETRICH railcars adorned with flags.

600-H.P. DE DIETRICH diesel-electric motor train, Algerian Railways. — Opening of the Biskra-Touggourt service on January 31st, 1939.

1 and 2 francs per km. (1.60 and 3.20 fr. per mile) according to the power of the car, compared with 4 to 5 francs per km. (6.40 to 8 fr. per mile) for steam operation.

In the case of the double 250/300-h.p. railcars used by the *Provence Railways*, the cost was 3.30 fr. instead of 9.10 fr.

Railways in Portuguese East Africa.

The six 140-h.p. diesel-electric railcars with 110 seats belonging to the Portuguese East African Railways work a total of 836 miles a day, and about 167 miles per day per car.

The *Michelines* used by the Mozambique Railways cover on the average 207 km. (128.6 miles) a day, and the *Hudson* railcars 63 km. (39 miles) a day.

(B) Meeting peak traffic with railcars.

This problem has two very different aspects according to whether it is a question of large capacity triple or quadruple railcars, or single or double railcars. Obviously with the former the necessary capacity can easily be obtained by coupling together two, three or four sets, like in Holland. The peak traffic problem is solved in this way without difficulty and without undue expense.

Here we will deal in particular with the problem of peak traffic working with single or double railcars, which concerns most of the Railways, and has been solved in various ways, at the cost of difficult and often expensive operating conditions.

We will leave aside the high-speed railcars normally employed for services with important traffic partly worked by express or semi-express steam trains at relatively frequent intervals : The Management can, in fact, limit the number of seats available on these special railcars when they are first introduced, and by giving the passengers facilities for booking their seats in advance, oblige the others to travel by the ordinary trains when the railcars are full up.

The only problem that will be investigated therefore is that of meeting peak traffic with single or double railcars working express services on cross-country lines, or a local service on secondary lines, in the place of the former steam trains. Here it is not usually possible to limit the number of seats offered, as the railway is obliged to carry all the traffic offering.

Technical solutions.

The various technical solutions suggested are :

(a) When a rush of traffic is expected, replacing the railcars by steam trains : a simple but expensive solution which supposes that the existing steam stock has been retained after the railcars were introduced, and is consequently badly used;

(b) Running an additional steam train after the railcar, over the often rather short section whereon the number of passengers exceeds the capacity of the railcar : this is the solution employed by the Belgian National Rys. Co. It is more ingenious, but just as expensive as the first;

(c) Adding to the railcar, when it has sufficient power, a trailer specially designed for this purpose or not : solution recommended in Rumania and France.

(d) Coupling the railcars together, with or without trailers in addition; this solution is often adopted in France and Italy;

(e) Running railcars kept specially available for traffic peaks, the maintenance work in the shops being specially organised to free as many vehicles as possible for days of rush traffic.

We will now consider each of these solutions in turn.

Solution *(a)* is often the only one possible when the traffic peak is particularly important. It involves frequent traffic delays, as the heavier trains cannot

run to the regular railcar timings. When used for cross country services, this drawback often becomes of great importance, as it is on such services that the railcar saves the most time.

Solution *(b)* which avoids some of the drawbacks of the previous solution, raises the same problem of the reserve stock and staff to be retained all the time, and getting them ready when wanted.

Solution *(c)*, if it is to be a real one, presupposes that a trailer is not normally required. In other words, the trailer must be available for peak traffic and not required for regular service (outside rush hours); in addition, it must be available at the right place, i.e. where an unexpected rush occurs; consequently the trailer is generally poorly utilised. There is also the drawback of having special trailers, which must necessarily be limited in number and so cannot be distributed amongst a large enough number of stations.

In addition, poor use will be made of the power of the railcar which can haul a trailer, on days when the latter is not required, unless the railcar can then be made to share in the goods traffic by hauling wagons, as do French standard railcars.

Solution *(d)* implies having specially designed or equipped stock (simple and ingenious solutions have been put forward during the last few years).

Solution *(e)*, which requires very careful organisation of the work in the sheds, means that the Running Department will have to deal with the problem of additional services, unless the cars can be coupled together. This problem is often insoluble on single-track lines, even if there is little traffic; it is difficult, and often very costly to solve on lines with heavy traffic (very close timings, leading to all sorts of delays, difficulty of accepting and shunting in large stations, expensive holding up and delays to goods trains, etc.).

The economic point of view.

Solutions *(d)* and *(e)* which assure the proper utilisation of the railcar stock are the most economical : unfortunately they are of limited efficiency, as the railcar stock which can be made available for periods of rush traffic amounts to 30 or 40 % at the most of the stock required for the regular services; on the other hand, single railcars can rarely be coupled up into sets of more than 3 cars.

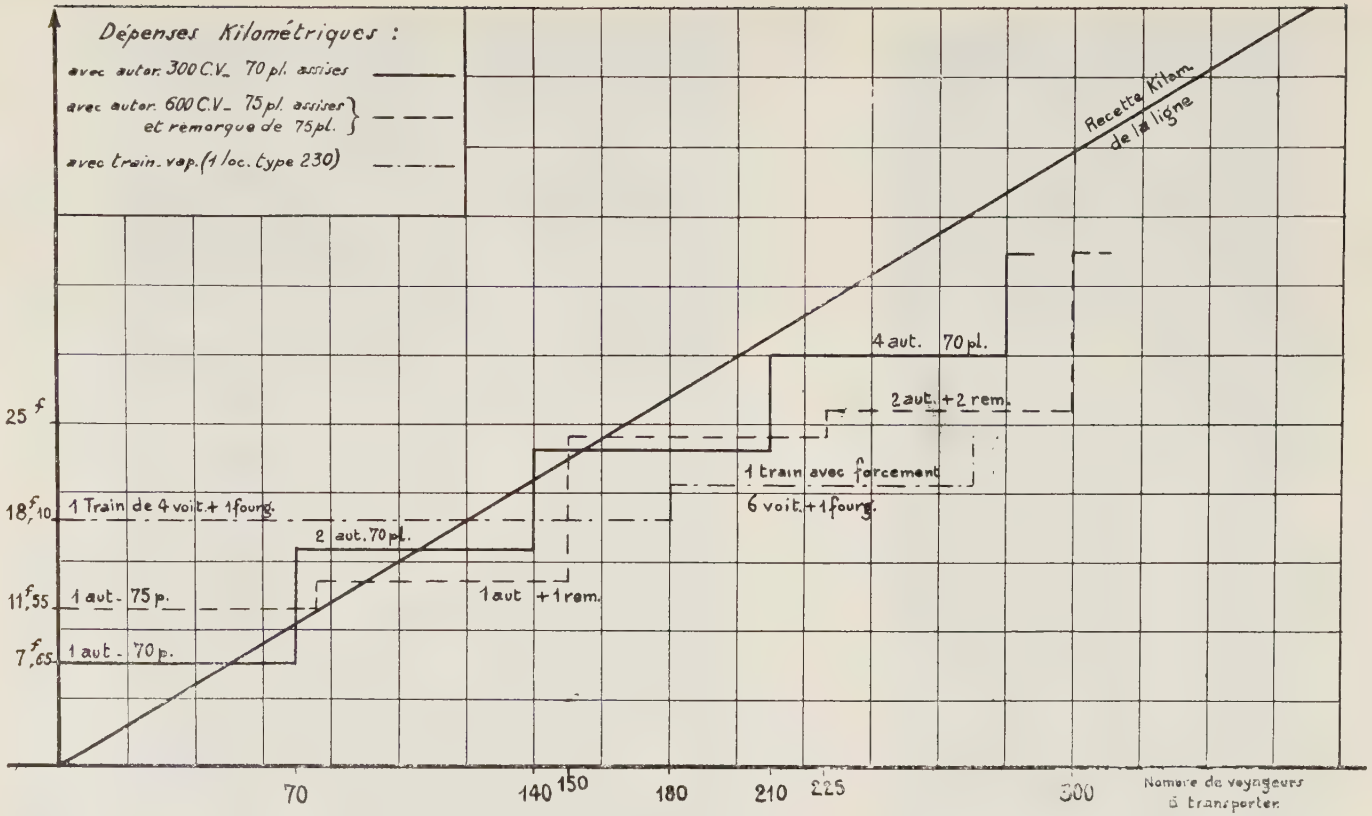
Certain services where 80 to 100 % of the seats are always occupied, at peak periods require 200-300 and even 400 % more.

The Railways calculate « co-efficients of replacement » equal to the quotient of the kilometric cost of the steam train and that of the railcar. As long as the number of railcar services does not exceed the product of the former train services by this coefficient of replacement, they generally admit that the expenses are equal, and that at the same time they reap the advantage of the greater number of passengers attracted by a more frequent service.

As a matter of fact, experience has shown that it is necessary to keep much below the theoretical coefficient of replacement, owing to the necessity for retaining steam stock for such peak periods, which has a very adverse influence on the balance sheet.

It is interesting to investigate from the theoretical point of view, taking only the inclusive operating cost into account, the real boundary between the field of the single and the twin railcar, and that of steam traction respectively.

With the aid of the kilometric costs given in Chapter IV hereafter for the types of railcars used by the French National Rys. Co. for the semi-express and local services and for the corresponding steam trains, it is possible to draw up the graph hereafter, showing the costs per kilometre of the services in terms



Explanation of French terms:

Left-hand top corner.

Expenditure per kilometre:

— with 300-H.P. railcar, 70 seats ——————

— with 600-H.P. railcar, 75 seats and trailer, 75 seats } ——————

— with steam train (one 4-6-0 locom.) — · — · —

In graph.

Recette kilom... = receipts per kilometre of line. — 1 train de 4 voit. + 1 fourg. = 1 train made up of 4 coaches and 1 van. — 1 aut.. 75 pl. = 1 railcar, 75 seats. — 1 aut. + rem. — 1 railcar + trailer. — 1 train avec forcement... — 1 train, composition increased to 6 coaches + 1 van. — Nombre de voyageurs... = number of passengers to be carried.

of the number of passengers to be carried.

Obviously the conclusions to be drawn from such a graph cannot be either formal nor of general application. But it does make it possible to define the elements of a balance sheet in the concrete case of a line with given traffic (average traffic, peak traffic).

Where the average traffic is less than 70 passengers per service, and the peak traffic is never more than double this number, a railcar with 70 seats (300 H.P.) is very advantageous, if the peak day requirements can be met by means of supplementary railcars made available for such days.

If the peak traffic is of about 150 passengers, a railcar with 75 seats — *Standard* 600-H.P. type — which can be coupled up with a trailer is indicated, but the cost of the service at slack periods is considerably increased. If the average traffic is 120 passengers and weekly peak periods greatly exceed 150 passengers, the single railcar which can be coupled up with another car or with a trailer is no longer an economical solution.

However, the advantage of the railcar from the point of view of speed may make it possible to exceed this theoretical boundary, especially in the case of feeder or pick up services which have the great advantage of better attracting the clientele towards the paying express services or make it possible to make savings on these express services (elimination of stops).

This graph brings out the rapid falling off of the economical value of the single railcar compared with the train when the number of passengers to be carried increases (this is important in the case of constant traffic, but still more so in the case of a very variable traffic).

The problem of peak traffic in practice.

To sum up, the problem of peak traffic is a matter of the number of seats available from certain given stations either at a definite hour (connections to be made) or in a fairly short period, a few hours for example.

The problem of peak traffic therefore is a problem of *available stock*, which must be ready at convenient points and hauled as cheaply as possible.

For the operating to be economical, the total stock must be as small as possible, i.e. a steam stock poorly used outside peaks periods should not be maintained side by side with a stock of railcars part of which is kept in reserve on sidings or in the depots on peak days.

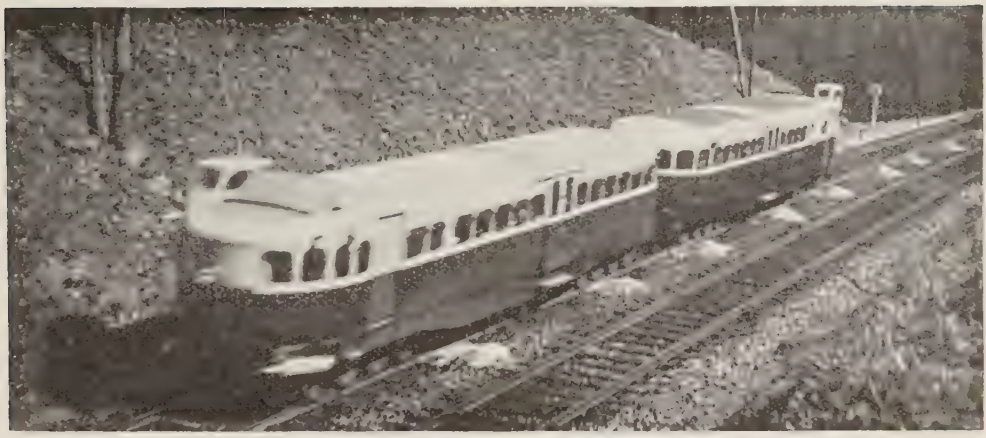
In the case of Companies possessing a big stock of railcars, the practical rules would appear to be as follows :

1. First and foremost the total stock of railcars must be used to the greatest possible advantage, i.e. the whole stock must be in working condition on days of peak traffic, the greatest possible number of services must be worked with this stock first of all (solution *e*) by coupling it together if the design permits, (solution *d*) in order to congest the running roads to the least possible extent.

2. Those railcars which can haul trailers, must be used for this purpose on days of peak traffic (if need be carriages of the old stock should be attached).

3. After this recourse may be had to the steam trains, but only in so far as the number of passengers to be carried exceeds the total number of seats in the railcars.

4. The Companies owing triple and quadruple railcars with 2nd and 3rd-class compartments, which can be coupled together, have no difficulty in meeting peak traffic with such stock, and consequently do not have to resort to steam traction on such occasions.



56-seater twin Michelines photographed at speed on the Paris-Brest line.

96-seater Micheline leaving the Saint-Lazare Station (Paris).

(C) Maintenance and garaging of railcars. Periods out of service.

1. Maintenance programme and time out of service.

Belgium.

The maintenance cycle is computed in months.

The average monthly distances covered are :

— 18 000 to 20 000 km. (11 200 to 12 500 miles) for the triplets for high-speed main-line services;

— 9 000 to 10 000 km. (5 600 to 6 250 miles) for the other railcars.

The maintenance programmes are as follows :

Triple railcars.

(a) Overhaul of the engine in the central shop and light overhaul of the bogies (taking up play in the boxes and brake rigging, if need be returning the guiding wheel tyres) — every 3 to 4 months [every 60 000 km. (37 300 miles) or over if possible];

(b) Overhaul of the engine at the central shop.

General overhaul of the railcar (in particular the electrical equipment);

Thorough overhaul of the bogies (squaring up, returning the tyres) — every 6 to 8 months (120 000 km. = 75 000 miles).

(c) Complete overhaul of the body (repainting the interior if necessary) — every two years.

(d) Complete overhaul of the body (repainting the outside if necessary) — every four years.

The labour required for maintenance is estimated as 26 man-hours per day, plus 48 man-hours per week for periodical inspection and small repairs, in the case of a triplet. In the case of a twin railcar, these times are 18 man-hours and 22 man-hours respectively.

The railcar is out of service :

— for weekly work : less than one day;

— every 3 months : 6 working days;

— every 6 months : 25 working days;

— once a year : 25 working days.

Single railcars (other services).

(a) Summary inspection of the bogies, returning the tyres — every 6 months;

(b) General overhaul :

Every year. — The body is repainted inside every two years, and outside every 4 years.

The labour required for this maintenance is estimated to be 12 man-hours per day plus 18 man-hours per week for periodical inspection and sundry repairs.

The railcars are out of service :

— for weekly work : 1 day;

— every 6 months : 6 days;

— every year : 12 days.

France.

The various operations follow the cycle given below :

General overhaul : after working 150 000 to 300 000 km. (93 000 to 186 000 miles);

Intermediate overhaul : half way between two general repairs in the case of railcars running 200 000 to 300 000 km. (125 000 to 186 000 miles) between general repairs.

Periodical inspections : after 25 000 to 30 000 km. (15 500 to 18 600 miles) and 3 000 to 5 000 km. (1 860 to 3 100 miles).

Daily inspection.

Occasional repairs.

The following remarks should be added :

(a) The mileages run between repairs are averages, the actual mileages varying a little according to the type of railcar, the service worked, the climatic conditions, garaging conditions, etc.

As regards the periodicity of heavy repairs, the aggregate distance covered

is preferably 240 000 to 300 000 km. (155 000 to 186 000 miles), with intermediate repairs after 120 000 to 150 000 km. (77 500 to 93 000 miles), this being more economical and keeping the railcars out of service a shorter time.

(b) The railcar workings are so drawn up that the vehicles are inspected after a mileage of 600 to 800 km. (370 to 500 miles) (according to the service worked), either in the depot to which they are worked, or better still, in the depot to which they belong.

The time taken for this is about 4 hours.

In addition, it is essential to make provision for holding the railcars in the home depot for about 8 hours every 1000 to 1 200 km. (620 to 750 miles) for sundry jobs.

(c) Every 3 000 to 5 000 km. (1 860 to 3 100 miles) there should be an interval of at least half a day, and if possible a whole day, in which the railcars can be held in the depots.

For the inspection after 25 000 to 30 000 km. (15 500 to 18 600 miles) a minimum of about 5 days must be allowed. These are the inspections that should be carried out as much as possible during the week, in order to make the railcar available for the extra traffic on Saturdays and Sundays.

Rumanian Railways.

General overhaul after every 70 000 km. (43 500 miles) worked.

The railcar is out of service :

3 hours daily for inspection and repairs;

4 days after 35 000 km. (21 750 miles) have been run;

10 days after 70 000 km. (43 500 miles) have been run.

Italian Railways.

Careful overhaul of the engines every 32 000 km. (20 000 miles).

The wear of the cylinders and bearings in particular is measured. This makes it possible to ascertain whether it is necessary to stop the railcar for heavy repairs at the end of the next 32 000-km. (20 000 miles) stage.

According to the type, these heavy repairs take place every 100 000 to 250 000 km. (62 000 to 155 000 miles).

They include lifting and checking all the power plant and the whole of the car equipment.

Careful periodical inspection every 8 000 km. (5 000 miles).

Simple overhaul every 4 000 km. (2 500 miles).

Netherlands Railways.

General overhaul every 115 000 to 120 000 km. (71 500 to 75 000 miles).

Periodical maintenance, every 7 days (after some 6 000 km. = 3 700 miles); set out of service for a day; engine and auxiliaries carefully gone over, as well as the electrical equipment, auxiliaries (and various light repairs), by a gang of 8 men.

Daily maintenance, 1 3/4 hours at the beginning and 1 1/2 hours at the end of the day, by one man. In service, during stops, 2 hours are devoted to checking the engines, brakes, couplings, and fuelling. During the night, 3 to 4 hours labour employed on inspecting the engines, light repairs, replacing brake shoes.

Days out of service for repair or periodical maintenance, 26 % of the days in service.

Algerian Railways.

General overhaul every 120 000 km. (75 000 miles).

Inspection every 60 000, 30 000, 4 000 km. (37 300, 18 600, 2 500 miles).

Tunisia.

In the case of standard-gauge railcars, general overhaul of the vehicle every

300-H.P. DECAUVILLE railcar working local services on the Versailles-Dreux section.

RENAULT A. E. K. railcar at the Noisy-le-Sec depot.

240 000 to 280 000 km. (155 000 to 174 000 miles).

The engines are exchanged every 120 000 to 140 000 km. (75 000 to 87 000 miles).

As regards narrow-gauge railcars, general overhaul of the vehicle every 100 000 to 120 000 km. (62 000 to 75 000 miles).

Belgian National Light Rys. Co.

A general overhaul every 150 000 to 200 000 km. (93 000 to 125 000 miles).

Light repairs every 40 000 to 50 000 km. (25 000 to 31 000 miles).

Djibouti — Addis-Abbaba Rys.

Complete overhaul of the engine required every 25 000 km. (15 500 miles) (stock of 4 Fiat railcars with two 115-h.p. diesel engines on two driving bogies).

2. Percentage of the stock of railcars in actual service.

The following table shows the percentages of days the railcars are out of service for maintenance, repairs, etc.

Railways.	Proportion of days out of service.
Belgium { triplets	21 %
Belgium { single units	22 %
France	27 %
Rumania	11 %
Italy	26 %
Belgian light Railways { Diesel	7 %
Belgian light Railways { Petrol	14 %
Algerian Rys.	25 %
Tunisian Rys. { standard gauge	28 %
Tunisian Rys. { narrow gauge	31 %

Consequently, 20 to 25 % of the stock of railcars is normally undergoing heavy repairs or overhauls in the shops. Taking into account the railcars kept as spare to meet the possible breakdown of a railcar in service, the number of railcars in regular service every day is only about 50 to 60 % of the total stock.

With the more recent types, working almost irreprochably, and the railcars grouped in a small number of depots, it does not appear necessary to have any cars in reserve, or a very lower proportion at most (for instance 5 % of the stock should be sufficient).

With the modern types of railcars, 75 % of the stock should be in regular i.e. in daily service.

3. Garaging railcars. — Maintenance. — Refuelling. — Protection against cold.

The great majority of the Railways assign each railcar to some particular depot, having adequate maintenance equipment, and to which its working programme frequently brings it back. Some Administrations endeavour to group the vehicles into as large as possible « railcar centres »; this means that the operating and maintenance conditions are then particularly satisfactory, owing to the great number of railcars under the control and management of one and the same organisation.

Nowhere does the distribution of the railcars amongst a small number of depots involve costly light mileage.

For protection against cold, the following steps are taken according to the climate :

— Closed and heated garages (steam radiators, hot air circulation, possibly a stove);

— Closed garages, not heated;

— « Catalytic » heaters in the engine rooms;

— Keeping the independent heating plant working, if the railcar is so equipped;

— light running of the engines at intervals during long stops.

All the Companies are gradually improving the equipment of the depots or railcar centres for refuelling, maintenance and preparation of the cars.

The most up-to-date installations include :

— Underground fuel tanks, centrifugal purifying or filtering equipment, fuel supplied from electric or hand pumps, or from compressed air pumps (worked by the railcar);

— Pressure oil and grease lubricators; pneumatic sandbox fillers; electric pumps for cleaning of the bogies and lower part of the body; battery recharging plant; equipment for checking the electrical apparatus; air pumps for the tyres (Michelines); stands at which the fuel injection pumps are checked and regulated, and the nozzles gauged; machines for grinding the valves; benches for testing the electro-valves of the starter, flexible pipes, etc. Special railcar washing plant; special handling and lifting devices (rocking cradles for holding the engines, jigs for use in repairing the details). Such extensive equipment is only justified in the case of fairly large centres.

— Equipment for pre-heating the railcars by air from a gasoil heater *(Italian Rys.)*.

(D) Annual mileage and amortisation of railcars.

1. Annual mileage.

In 1937 (page 1435/1913 of our report) (1) we stated that the annual distance covered by the most-up-to-date railcars generally exceeded 100 000 km. (62 000 miles), and reached 132 000 km. (82 000 miles) per vehicle in the case of the most fully used railcars.

These figures are in themselves rather low, and much lower than those for similar stock on the American Railways.

This is due to the fact that in these parts the Operating Department rarely has to work a series of long-distance railcar services : the most favourable service investigated for railcars and tested several times (though it has never actually been introduced owing to the economic crisis) was the Paris-Boulogne-Basle service, the up journey being made the following day, using a triple railcar, the whole journey representing about 1 200 km. (750 miles) per day. There is no doubt that such a service, which would have meant 3 or 4 successive locomotives with steam traction, would have really proved the worth of the railcar and given extremely interesting total costs.

In practice in Europe a stock of railcars which has to assure all sorts of services, express and local, is hard put to it to exceed an average of more than 300 km. (186 miles) per day per vehicle of the stock. The figure of 401 km. (249 miles) has however been obtained as an average in the case of the 40 Dutch triplets; and that of 260 km. (161.6 miles) was kept up by the French Rys. (Northern Area) during the first 9 months of 1938, as an average for its 83 railcars.

During the same period, the Western Area, with its 230 railcars did not exceed 220 km. (136.7 miles) on the average per railcar (whole stock). The Belgian average is 225 km. (139.8 miles); the Italian is 202 km. (125.5 miles) (probably on account of the large proportion of secondary services).

The average mileages would be appreciably higher if the railcars were grouped in a smaller number of depots, as each depot has to keep one railcar in reserve to meet breakdowns which are becoming more and more rare, so that one spare railcar for every 40 to 50 in service should be sufficient in practice.

2. Total mileage of the oldest railcars.

In 1937 (page 1434/192) we also gave the total mileage of the oldest classes of railcars, this being nearly 600 000 km. (372 000 miles) per vehicle for certain

(1) Bulletin of the Railway Congress. May 1937.

Belgian classes, and 300 000 km. (186 000 miles) for certain French classes.

These figures have been greatly exceeded to date, as the opposite table shows.

In view of the present condition of these vehicles, which generally speaking is excellent both as regards the bogies and body framework, and the motor gear, it seems likely that the series listed in this table will be out of date or too old to be maintained in their present services long before they are worn out.

—	Date put into service.	Average mileage per railcar in the class at the end of 1938, km. (*miles*)
Belgium		
3 *Sentinel.*	1930	673 199 (*418 314*)
2 *EVA Malbach* . . .	1930	730 605 (*466 413*)
14 *La Brugeoise-Maybach*	1933	489 923 (*304 430*)
1 *A.S.E.A.*	1932	587 690 (*365 180*)
3 *La Brugeoise-Maybach* triplets	1936	290 663 (*180 613*)
3 *Baume et Marpent* triplets	1936	255 982 (*159 063*)
France.		
36 *Renault V.H.* (West. Area).	1934	438 107 (*272 232*)
10 *Renault A.B J.* (North. Area)	1936	312 672 (*194 289*)
8 *Michelines*, 36-seater .	1933-35	441 317 (*274 226*)
8 *de Dietrich*	1935	332 030 (*206 318*)
16 *Aciéries du Nord* . .	1936	202 377 (*125 754*)
10 *Bugatti*, 800 H.P. .	1933-36	299 385 (*186 033*)
6 *Charentaises*	1933-34	362 318 (*194 069*)
8 *Franco-Belge, T.A.R., etc.*	1936	254 544 (*158 169*)

3. Amortisation of railcars.

The question of the amortisation of railcars is very important, since it is an essential factor in the total cost. The Managements have prudently included in their calculations low conventional mileages for calculating the depreciation charges per mile worked.

The table below gives the railcar life reckoned by various Companies for calculating the total cost per mile.

(E) Railcars under construction.

The question of comfort.

Table F shows the chief types of railcars under construction for the various Railways, giving as far as possible the number of units in service, under construction, or proposed.

Administrations.	Type of railcar.	Amortisation provided for after	Remarks.
France . . .	High-speed services.	1 200 000 km. (*745 700 miles*)	Certain low-powered railcars, of old design, light construction, not comfortable, were written off after about 500 000 km. (*310 000 miles*).
	Express services.	900 000 km. (*559 200 miles*)	
	Local services.	700 000 km. (*435 000 miles*)	
Belgium . . .		Engine and transmission 10 years.	Certain engines have been in service 10 years already and appear likely to last 20 years.
		Coachwork, 30 years.	A metal body may last 40 years.

Administrations.	Type of railcar.	Amortisation provided for after	Remarks.
Italy	Light bogie railcars with petrol engine.	8 years.	According to the first calculations the life was not expected to exceed 6 years (500 000 km. = *310 000 miles)*) for the first railcars which were of very light construction. Experience has shown that careful maintenance gives a life of more than 8 years. It may be admitted that the railcars will be out-of-date as a type before their actual condition makes it necessary to scrap them.
Jugoslavia . .	...	1 000 000 km. *(621 400 miles)*	350 000 km. *(217 500 miles)* for the power plant.
Belgian Light Rys.	...	1 000 000 km. *(621 400 miles)*	...

First of all here are some figures showing the increase in the numbers of railcars during the last few years :

—	*Belgium.* National Rys. Company.	*France.* National Rys. Company.	*Holland.*	*Italy.*	*Rumania.*	Total.
1932	7	24	0	6	23	60
1933	22	34	0	15	31	102
1934	31	88	28	95	31	273
1935	32	230	40 (1)	164	100	566
1936	42	354	40 (1)	291	182 (2)	909
1937	42	537	40 (1)	450	200	1 269
1938	42	645	48 (1)	579	207 (2)	1 521
1939 (April)	42	700	48 (1)	579	207 (2)	1 576

Table F shows the tendency amongst the different Railways to reduce the number of types.

In the future, *Belgium* is considering the extension of four-wheeled 15-ton railcars for secondary lines.

France is concentrating in particular on two types of railcars, both bogie vehicles, one derived from the standard 5/600 H.P. type, capable of hauling 45 to 50 t. (44.2 to 49.2 Engl. tons) at 100 km. (62 miles) an hour on the level and at 75 km. (46.6 miles) an hour up a 1 in 100 gradient, and the other of about 300 H.P. with 75 seats, with a maximum tare

(1) 40 of which are triplets.

(2) 99 of which are carriages equipped with an internal-combustion engine.

TABLE F.

Leading characteristics of railcars under construction.

—	BELGIUM. — *National Rys. Co.*						FRANCE. — *National Rys. Co.*						NETHERLANDS.	ITALY.		RUMANIA.				BELGIUM. *National Light Rys. Co.*
Constructional features of recent railcars, in service or being built.	On order.	On order.	On order.	In service.		On order.	In service and on order.	In service and on order.	In service or on order.	On order.	In service or on order.	In service.	On order.	In service and on order.		In service.	In service.	In service or on order.	[illegible]	Railcars for secondary line services.
	Triplets for high-speed services.	Twins for express, semi-express and local services.	Bogie simple railcars for semi-express and local services.	Single railcars for secondary lines, with : 4 wheels.	2 bogies.	Single four-wheeled railcars for secondary lines.	Single Renault A.B.J. bogie railcars. Semi-express and local services.	Single Renault A.E.K. bogie railcars. Semi-express and local services.	Standard railcars for semi-express and local services, with trailer.	de Dietrich « monocoque » type railcars derived from the bogie railcars in service.	Type 23 [illegible] Michelin pneumatic tyres. High-speed, semi-express and local services.	Bugatti triple railcar for high-speed services.	Five-car sets which can be coupled to each other or to the existing triplets.	Various type of bogie single railcars.		Four-wheeled carriages equipped with an engine.	Modern 4-wheeled railcars (Malaxa, Astra or Unio).	Astra streamlined bogie railcars.	Malaxa twin railcars.	
Number { in service . on order .	8 6 (1)	1 12 (1)	28 6 (1)	6 ...	6 ...	... 50 (2)	88 21 AD X 2	22 ...	41 16	0 monocoque. 2 monocoque + 14 de Dietrich of various designs.	15 6	5 + 2 ...	... 18	Fiat A.L.N. 56 about 250	Breda A.L.N. 56 about 100	99 ...	83 ...	7 ...	... —	270
Number of seats available	219	136	64	50	80	50	44 (1/2) to 70 (3)	78	88	55-100	100	143 and 164	...	56	56	...	59	...	136	24
Weight, empty. Metr. *(Engl.)* ton	138 *(135.8)*	96 *(94.5)*	45 *(44.3)*	14 *(13.8)*	21 *(20.7)*	14 *(13.8)*	in working order: 29 to 31 *(28.5 to 30.5)*	in working order: 24.5 *(24.1)*	39 to 49 *(38.4 to 48.2)*	Estimated : 31.5 *(31.1)* for 28-m. *(91 ft. 10 3/8 in.)* length.	17 *(16.7)*	70 and 80 *(68.9 and 78.7)*	...	20 *(19.7)*	24 *(23.6)*	...	24 *(23.6)*	in working order : 35 *(34.4)*	in working order : 84 *(82.7)*	—
Weight per seat, kgr. *(lb.)*	650 *(1 433)*	713 *(1 572)*	708 *(1 561)*	280 *(617)*	275 *(606)*	280 *(617)*	554 *(1 221)*	404 *(891)*	828 *(1 825)*	570 *(1 257)*	180 *(397)*	555 *(1 223)*	...	235 to 680 *(518 to 1 499)*		440 to 500 *(970 to 1 102)*	340 *(750)*	...	620 *(1 367)*	450 *(990)*
Power/weight ratio (H.P. per ton)	7.6	6.6	6.7	6.5	4.3	6.5	10.4	9.5	12.7	10.1	23.1	10	...	7.4 to 12.7		5.7 to 7	6 to 7.5	6.3	5.5	8 to 12
Number and arrangement of wheels	2 motor bogies, 4 carrying bogies.	2 motor bogies, 1 intermediate carrying bogie.	1 motor bogie, 1 carrying bogie.	1 pair of driving wheels.	2 motor bogies, each with one pair of driving wheels.	1 pair of driving wheels.	1 motor bogie, 1 carrying bogie.	2 bogies, each with one driving pair of wheels.	2 motor bogies (total adhesion).	2 motor bogies.	1 motor bogie in centre. 2 carrying bogies.	1 power vehicle in middle, with two eight-wheeled bogies each with 2 driving pairs of wheels; 2 trailers with eight-wheeled carrying bogies.	...	2 motor bogies or 1 motor and 1 carrying.		2 pairs of wheels, 5.30 m. and 8.50 m. *(17 ft. 5 in.)* and *26 ft. 3 in.)* wheelbase. 1 pair driving, 1 carrying.	2 pairs of wheels, one driving, one carrying, 8.50 m. *(27 ft. 10 1/2 in.)* wheelbase.	1 motor bogie. 1 carrying.	2 motor bogies. 2 carrying.	2 pairs of driving wheels.
Kind and power of engines.	2×600 H.P.	2×365 H.P.	365 H.P.	135 H.P. Brossel.		135 H.P. Brossel.	1 × 265 H.P. or 1 × 300 H.P. diesel.	2 × 150 H.P. diesel.	1 × 265 H.P., 2 × 265 or 300 H.P. diesel.	2 × 160 H.P. Saurer-diesel.	400-H.P. petrol.	4 × 200 H.P. Bugatti, petrol.	3 Maybach supercharged 650-H.P. diesel engines in line in one compartment.	2 × 80 H.P. Fiat diesel.	2 × 115 H.P. Breda diesel.	1 × 120 H.P. 150 H.P. or 220 H.P.	1 × 120 H.P. or 150 H.P.	1 × 220 H.P. diesel.	2 × 220 H.P. diesel.	...
Type of transmission. .	Hydraulic, Voith.	Mechanical. Winterthur or Cotal gearbox.	Mechanical. Winterthur or Cotal gearbox.	Mechanical. Brossel gearbox.		Mechanical. Brossel gearbox.	Mechanical. 4 synchronised speeds gearbox.	Mechanical. 4-speed gearbox.	Mechanical. Winterthur 5-speed gearbox.	Mechanical. Mylius 5-speed gearbox.	Mechanical. Cotal 4-speed gearbox.	Mechanical with Cotal 2-speed gearbox.	Electric.	Mechanical, with Fiat or Wilson gear box. Hydraulic transmission being tested.		Mechanical. Méadoros, M.A.N., T.A.G. or Mylius gear box.	Mechanical. Mylius gear box.	Mechanical. Mylius gear box.	Mechanical. 5-speed gearbox.	Mechanical with gear box. Differential to ensure the independence of worm-driven axles.
Maximum speed, km. *(miles)* p.h.	150 *(93)*	120 *(75)*	120 *(75)*	60 *(37.5)*		60 *(37.5)*	120 *(75)*	120 *(75)*	120 *(75)*	120 *(75)*	120 *(75)*	140 *(87)*	140-160 *(81-100)*	...		...	85 *(53)*	110 *(68)*	110 *(68)*	65 *(40.5)*

(1) The characteristics relate to railcars under construction.

(2) Out of 150 provided for.

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140-h.p. 80-seater 4-wheeled Brossel railcar for secondary lines, Belgian National Rys. Co.

Interior of Brossel 80-seater railcar.

Driving cabin of BROSSEL railcar.

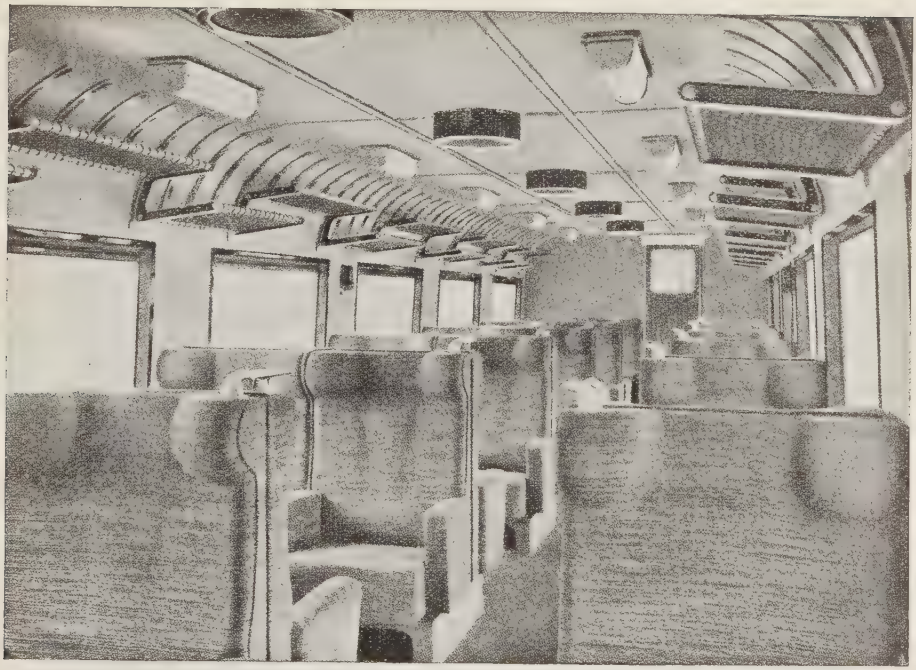
of 35 t. (34.4 Engl. tons) which can run as twins at 120 km. (75 miles) an hour on the level and at 60 km. (37.3 miles) an hour up a 1 in 50 gradient.

Holland is adopting five-unit sets which can be coupled up with the triple sets.

In *Italy,* where a series of 200 identical vehicles have been ordered, all with two engines, of a very light type, capable of hauling trailers, a body is now being designed capable of being used with different types of engines.

In *Rumania,* where the whole stock with the exception of 7 units consists of four-wheeled vehicles, it is now proposed to develop the eight-wheeled type.

* * *



Interior of Breda electrotrain.

As regards railcars under construction, one of the chief preoccupations of the Railways is to give passengers at least the same *comfort* as on the trains.

The problems of heat and sound insulation, interior arrangement (open or closed compartments), heating and ventilation, are being solved after careful research and in the most up-to-date way. These questions were dealt with in detail in our 1937 report, so we will not discuss them one by one.

Amongst the problems relating to comfort, the most important in our opinion for railcars, as well as for locomotives and passenger coaches, is the good riding of the vehicles, and in particular the absence of any hunting. This problem is indeed inseparable from that of safe running at the very high speeds now practised.

In several countries *(France and Holland)* hunting has been eliminated by using cylindrical tyres instead of the ordinary tyres coned 1 in 20; other Companies have adopted an intermediate solution, with a 1 in 40 or 1 in 100 coning. These cylindrical or slightly coned tyres are now in current use.

Whether or not the tyres are made cylindrical, it is a good thing to have the bogies constructed in such a way that they will not themselves give rise to any hunting movements.

The solution adopted in France for the *Michelines* as well as for certain other types of railcars (*Bugatti* and *Standard* railcars) and recently on the electric motor coach for pick-up services on the Paris-Le Mans line, which consists in making the body rest not on the bogie centre but on two lateral guides, deserves special mention, as up to the present it has given satisfaction as regards

the absence of hunting at the speeds of 120 km. (75 miles) an hour and over, practised with these vehicles.

* * *

CHAPTER IV.

Results of the passenger service improvements.

(A) Development of the traffic as a result of improved services.

The Railways covered by this report do not possess sufficient statistical data to calculate with certainty the development of the traffic due to all the improvements introduced in the services during the 1934-1938 period.

In a great many particular cases, however, countings have been made in the course of the months following the improvement of the service on certain lines. Then the variation in the traffic on these lines has been compared with that of the traffic over the whole system, and an endeavour has been made to draw conclusions therefrom.

In *Belgium,* the Belgian National Rys. Co. found that after the electrification of the Brussels-Antwerp line there was an increase in the passenger-miles of 32 % between 1934 and 1938 compared with an increase of 22 % for the system as a whole.

In *France,* the Northern Area found that as soon as the Franco-Belge triplets were put into service on the Paris-Lille line, the falling off in the number of 1st and 2nd-class passengers was less marked on this line than on all the other lines in the Area; in the following years this traffic even increased, whereas the traffic as a whole continued to fall off. Here are some of the results :

(1) In July 1934 — introduction of a high-speed motor train service between Paris and Lille and back.

1934 traffic:
- Number of 1st and 2nd-class passengers carried on the System as a whole : Decrease of 12 %.
- Number of 1st and 2nd-class passengers on the Paris-Lille line : Decrease of 3 %.

(2) In July 1936 — introduction of a second 2nd-class service between Paris and Lille and back.

In October 1936 — a fast steam train service was changed into a high-speed motor train service between Paris and Lille and back.

1936 traffic:
- Number of 1st and 2nd-class passengers carried over the whole System : Decrease of 7 %.
- Number of 1st and 2nd-class passengers carried on the Paris-Lille line : Increase of 3 %.

The Western Area of the French National Railways made some interesting observations on its Paris-Havre and Paris-Le Mans main lines.

On the former, in May 1936 the trains between Paris and Rouen had to be speeded up and the number of services increased in order to meet road competition and recover lost traffic; the new operating method consisted in discontinuing the stopping trains, which were slow and expensive, increasing the number of express and semi-express trains, and serving the intermediate stations by means of railcars giving good connections at the stopping points of the semi-expresses.

From May 1936 to July 1938, the daily mileage of the trains and railcars increased as follows :

Before May 15th, 1936 :

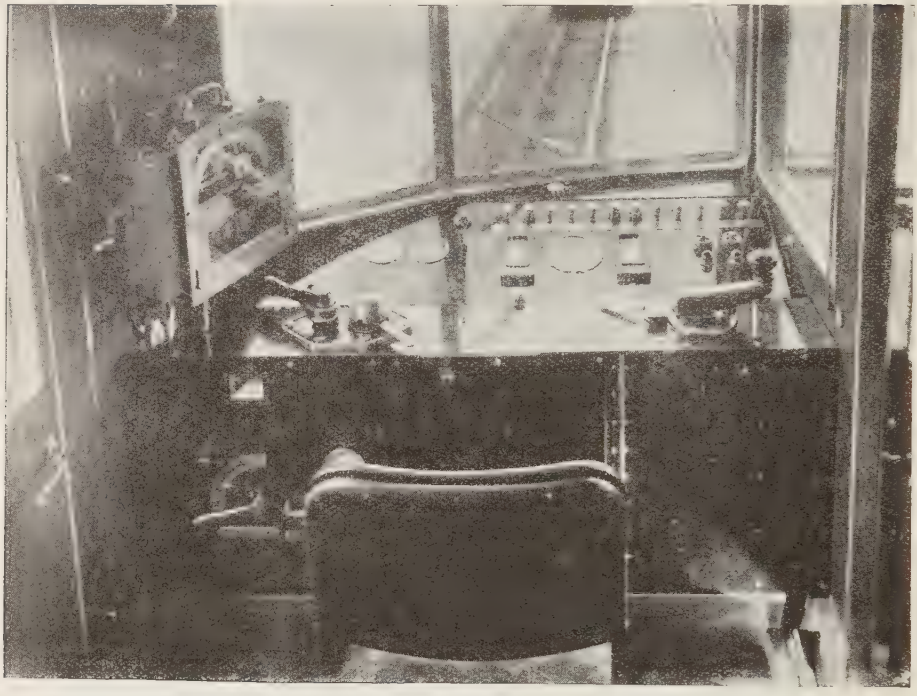
Steam trains . . .	3 880 km. *(2 411 miles)*
Railcars	1 125 km. *(699 miles)*
Together . .	5 005 km. *(3 100 miles)*

First-class compartment of stainless steel high-speed railcar of the French National Rys. Co. (Western Area).

In July, 1938 :	
Steam trains	4 350 km. *(2 703 miles)*
Railcars	1 596 km. *(992 miles)*
Together	5 946 km. *(3 695 miles)*

It should be noted that this increase of 18.8 % in the mileage was brought about more in order to foster new traffic than to meet an actual increase.

On the other hand, a comparison



View of driver's cabin of type 136 MICHELINE electric motor coach.

made between the number of tickets issued by the stations on this same line during the months of August 1935 and August 1936 showed that there was an increase of 20.2 %, which seems to prove that the improved services actually found favour with the public.

On the Paris-Le Mans line, the speeding up of the trains and the increase in the number of services took place in 1937 when this line was electrified. Not only has the train mileage increased [before May 1937 : 6 328 km. (3 876 miles) for the steam trains and railcars daily; in July 1938 : 9 294 km. (5 775 miles) for the electric trains], but the composition of the trains has been increased. Over the whole of the Chartres-Le Mans section (excluding both these stations) there has been a considerable increase in the total number of passengers carried; the figures for 1936 and 1937 show an increase of more than 15 %.

The South-Eastern Area of the French National Rys. carried out a very interesting experiment on the Lyons-Grenoble line.

During the first few months after the railcars were put into service, when they only worked two additional services (1) (as the P.L.M. had not a sufficient number of railcars available), not only were the traffic and receipts not improved, but they continued to decline as before, as the additional capacity of 50 and 60 seats offered by these railcars was obviously insufficient, compared with the total volume of traffic previously taken away from the railway by the

(1) There were 27 services at that date.

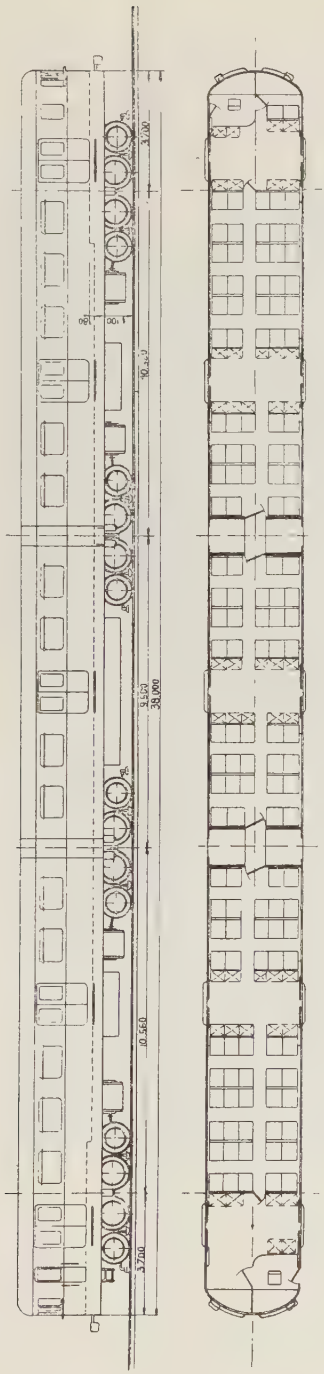


Diagram of type 136 Michelin electric motor coach.

road services on this route. When the P.L.M. was able to multiply the services, however, the decline in the traffic was stopped, and afterwards the number of passengers and receipts began to increase. This increase became still more marked when the number of services was increased in turn to 33, 42 and then 46. The increase in the passenger receipts under these conditions was 1.84, 8.16 and 13.54 % respectively.

The French National Rys. also obtained the following results on three other sections :

11 % increase in the receipts after the number of services between Pontarlier and Gilley was increased from 3 to 5;

33 % increase in the passenger-miles after the railcar mileage was increased by 41 % on the Compiègne-Roye line;

43 % increase in the passenger-miles after the railcar mileage was increased by 67 % on the Compiègne—La Ferté-Milon line.

The *Rumanian Railways* found that their passenger traffic increased by 50 % on the lines with little traffic, after railcars were put into service.

The *Italian Railways* consider that the traffic over medium distances has greatly increased as a result of the speeding up of the services. As a matter of fact, they were led to increase as from the 1st January 1939 the maximum limits for the issue of certain kinds of tickets [week-end tickets available for 500 km. (310 miles) instead of 250 km. (155 miles) — seasons for officials and students, 200 instead of 100 km. (124 instead of 62 miles) — rural market return tickets for 150 instead of 100 km. (93 instead of 62 miles)]. No information can yet be given about the results of these measures which were taken recently.

The *Belgian National Light Rys. Co.* has found that there was an increase of 10.7 % in the number of passengers in 1936 compared with 1935, and 5.8 % in 1937 compared with 1936 after the reorganisation of the services (passengers

by railcar, goods by steam train) over 3 376 km. (2 977 miles) of lines. The increase in the mileage was 19.7 in 1936 compared with 1935 and 4.2 % in 1937 compared with 1936; the difference between the unit costs of steam trains and railcars nevertheless made it possible to reduce to 62 the number of lines showing a deficit whereas formerly 84 out of 166 were worked at a loss.

French Secondary Railways. — The results obtained by the substitution of railcars for steam train services are remarkable : the increase in the passenger traffic is 30 to 40 % on the average, and in certain cases much more. We may mention in particular the *Provence Railways* (Toulon—St.-Raphaël line) which in two years (1934 to 1936) doubled its traffic.

The *Indo-China and Yunnan Rys.* give the following record figures relating to the results of putting into service :

— 5 railcars including 1 Micheline in 1935,

— 1 railcar in 1936,

— 1 Micheline in 1937,

for traffic where there is no 4th class (in the latter case the steam train has no competitors) between Hanoi and Haifong (102 km. = 63.4 miles) and on the Yunnan line.

		Passenger-km.	*Passenger-miles.*	Receipts.
Haifong-Hanoi line . . .	1933	1 895 156	*1 177 616*	40 561.21 $ (1 $ = 10 francs).
	1938	13 935 136	*8 659 048*	137 612.79.
Ho-K'eou-Yunnanfou line .	1933	924 374	*574 390*	22 064.97.
	1938	2 225 204	*1 382 703*	105 713.52.

Road competition on the former line has been completely overcome.

The *Franco-Ethiopian Djibouti to Addis-Abbaba Ry.* which greatly improved its passenger services between 1934 and 1938 (shortening the journey time between Djibouti and Addis-Abbaba from 35 to 23 1/2 hours thanks to the substitution of railcars for the steam trains) has not experienced any increase in the receipts attributable thereto. Unlike in the previous example, no traffic has to be recovered from road competition.

The *Tunisian Railways Co.* who has to meet very serious road motor competition, due above all to the fine highway system in that country, in 1936 made very great improvements to its passager services by introducing railcars on its two main lines (Tunis-Bizerte and Tunis-Ghardimaou).

After a year of these new services, the increase in the receipts was 9 % on the Tunis-Ghardimaou line, and 16 % on the Tunis-Bizerte line. The rates, which are much higher than the road service fares, remained unaltered, so that this increase is due entirely to the improvements made to the service.

* * *

The remarks and figures given above show that when the number of services is increased or the services are improved from the point of view of speed, convenience or comfort, there is generally an appreciable increase in the number of passengers, but this increase depends a great deal more on local conditions of competition and the fares in force than on technical methods used. The railway is only certain to profit if the service

4 Dutch diesel-electric triple railcars coupled together to form a 12-coach train.

can be improved without any additional expenditure which as a rule implies the introduction of new traction methods or the alteration of the operating methods.

(B) Comparison of the cost per mile of trains and railcars.

We will deal in turn with the services on secondary lines and the high-speed services, then we will compare steam trains and electric trains.

In our 1937 report, we concluded that in a general way the cost per mile for a railcar was about 60 % of that of the replaced steam train, pointing out at the same time that, as the capacity of a railcar was always smaller than that of a steam train, the cost per seat in the railcar might be higher than that of a seat in the steam train.

In order to give in the present report figures as accurate as possible, we drew up in agreement with our English and German co-reporters a detailed questionnaire which was sent to all the Railways concerned. From most of them we received very valuable replies for which we wish to express our very best thanks.

1. Railcars for other than high-speed services.

Belgium.

In 1937 we said that the cost of a railcar service was about 60 % of that of a steam train. The figures given for 1938 give an exact ratio of 59 %, which confirms our previous report.

France.

According to the costs for the Est System, we stated that the ratio for the 56-seater *Michelines* and 210-H.P. *de Dietrich* railcars was 60 %.

The 1938 figures show a ratio of only 30 % in the case of 80-100 H.P. single four-wheeled railcars with 35 seats, 42% in the case of 250-300 H.P. bogie single railcars with 60 to 70 seats, and 75 % for *Standard* railcars able to haul another vehicle, i.e. with practically the same capacity as a light train.

The 1938 figures therefore show a more favourable total cost for railcars on the secondary lines than the previous report.

A comparison of the purchase prices in present values of the various rolling stock is also much in favour of the railcar : a single-unit four-wheeled railcar costs about 600 000 francs; a single-unit two-bogie railcar costs between one and one and a half million francs; a *Standard* railcar costs less than 2 Millions; on the other hand a metal coach costs at present more than a million, and a train consisting of a locomotive, a van and two metal coaches costs nearly five millions, nearly double the price of a *Standard* railcar and its trailer.

Italy.

A single-unit bogie railcar with 56 seats costs 2.35 lire per km. (3.78 lire per mile) worked, whereas a speeded up steam train consisting of a locomotive and two coaches costs 4.92 lire per km. (7.92 lire per mile), i.e. over 100 % more.

Table G gives the detailed costs of railcars on the secondary lines of the various Managements and of the corresponding trains.

2. Single or twin railcars for high-speed services.

France.

The comparison was made between a 500-600 H.P. diesel-mechanical twin unit with some 100 seats, such as the double *Renault* type for example, and a fast train of four bogie coaches and van, with 290 seats.

The cost per kilometre is definitely in favour of the railcar, as it is 50 % of that of the train; the cost per seat however is in favour of the train.

Italy.

Ultra high-speed services are worked by *Fiat* or *Breda* single railcars running

TABLE G.

Comparative total costs of railcars and trains working other than high-speed services.

	BELGIUM.		FRANCE.				NETHERLANDS.		ITALY.		RUMANIA.	TUNISIA.		JUGOSLAVIA.		DAMAS-HAMAH RY.	FRANCO-ETHIOPIAN RAILWAY.		INDO-CHINA AND YUNNAN RAILWAYS.			MOZAMBIQUE RAILWAY.			BELGIAN NATIONAL LIGHT RAILWAYS CO.		
Train composition	Single diesel-mechanical bogie railcars, 175 H.P. type 601, 104 seats.	Train made up of 1 locom. one 1st/2nd class 46-seater coach, 2 3rd-cl. 50-seater coaches—wooden plate-sheathed bodies), 146 seats together.	A-class single diesel-mechanical 4-wheeled railcars, 80 to 100 H.P. 35 seats.	B-class single diesel-mechanical bogie railcars, 250 to 300 H.P. 60 to 70 seats.	C-class single diesel-mechanical bogie railcars, with special trailer; 500 to 600 H.P. 150 seats together	Train made up of one 4-6-0 locomotive, four 4-wheeled coaches, 1 van, 180 seats together.	Diesel-mechanical railcars, 71 seats.	Train consisting of 1 locomotive 1 lugg. van, 4 coaches, 300 seats.	Fiat and Breda ALn 56 bogie single diesel-mechanical railcars, 56 seats.	Light speeded-up steam train made up of a locomotive and 2 coach. 176 seats together.	Single four wheeled 120-H.P. and 150-H.P. diesel railcars, 59 seats.	Single Renault A.B.J. diesel mechanical 265-H.P. bogie railcars 70 seats.	Steam train consisting of one class 181 locomotive, 3 coaches, 1 van Together 222 seats.	Diesel-mechanical triple railcar for 2 ft. 5 7/8 in. gauge, 87 seats together.	Steam train consisting of 1 locomotive, 6 coaches, 2 vans 132 seats together.	de Dietrich railcars with two 105-H.P. engines. Speed restricted to 85-90 km. (53-56 miles) p.h. 50 (+) of cats as spare. 71 seats.	Fiat railcar with 2 motor bogies. 115 H.P. 27 seats.	Steam train made up of Semi-express one 1st/2nd class, 400 three 3rd class coaches (spaces one 1st/2nd class saloon 28 seats.	Decauville railcars with 1 or 2 Saurer diesel 140-H.P. engines. 55 seats	Metalvic 24-or 48-H.P. petrol cars 13 and 27 seats (or pro[illegible]	Light steam [illegible] 140 H.P. [illegible]						
...	Cost of railcar, in Belgian francs.	Cost of steam train, in Belgian francs.	Cost of railcar in French francs.	Cost of railcar in French francs.	Cost of motor-train in French francs.	Cost of steam train, in French francs.	Cost of railcar, in florins.	Cost of steam train, in florins.	Cost of railcar, in lire.	Cost of steam train, in lire.	Cost of railcar *exclusive of depreciation* in lei.	Cost of railcar, in French francs.	Cost of steam train, in French francs.	Cost of railcar, in dinars.	Cost of steam train, in dinars.	Cost of railcar, in francs.	Cost of railcar, in lire.	Cost of steam train in francs.	Cost of railcar, in francs.	Cost of railcar, in francs.	Cost of steam train in francs.	[illegible]	[illegible]	[illegible]	Cost of [illegible] francs.	[illegible] in Belgian francs.	Cost of [illegible] in Belgian francs.
Total cost per train-kilometre	3.96	6.72	5.40	7.65	13.15	18.10	0.32[25]	0.81[30]	2.35	4.92	7.18	2.85	13.40	14.09	15.11	2.70	8.55	13.75	2.0337	2.333	3.83	3.72	5.3	17.63 escudos	3.00	3.702	0.832
Total cost per available seat-kilometre	0.038	0.046	0.154	0.11	0.09	0.10	0.00[45]	0.00[27]	0.042	0.028	0.12	0.04	0.06	0.162	0.114	0.038	0.32	0.28	...	...	...	*(a)* 0.18 *(b)* 0.12	0.3	0.124	0.125	0.062	0.084
Purchase price at present value	1 387 000	1 668 000	600 000	1 000 000 to 1 600 000	1 700 000 + trailer	3 050 000	112 000	238 000	480 000	1 609 000	...	900 000	2 422 000	4 472 000	6 075 000	1 500 000 1937 value.	450 000	2 200 000	711 000	342 000 511 000		[illegible]	[illegible]	[illegible]	2 [illegible]	[illegible]	[illegible]
Detail of total cost per train-kilometre																											
Driving (driver, fireman)	0.57	1.18	0.72	0.72	0.80	1.70	0.04	0.14[06]	0.35	0.79	3.03	0.588	1.588	1.12	1.90	0.42	4.04+A+B	1.70	0.0584	0.5375	0.32				0.291	0.443	1.658
Fuel	0.37	1.76	0.55	1.29	2.51	3.20	0.02[7]	0.14[40]	0.27	1.54	0.98	0.219	3.161	2.02	3.09	0.13	1.00	4.42	0.3649	0.6365	1.32	...			0.297	0.768	1.308
Management and service in sheds	0.19	0.30	(in driving)	(in driving)	(in driving)	0.60	0.04[57]	0.10[78]	0.14	0.41	...	0.058	0.159	0.82	0.82	0.35	A	1.58	0.85	0.85	0.85				0.194	0.220	0.581
Lubrication and sundry materials	0.08	0.07	0.09	0.19	0.31	0.20	0.01[3]	0.00[27]	0.05	0.16	1.15	0.160	0.552	0.99	0.72	0.16	0.31	1.65	...	...	0.05				0.073	0.010	0.071
Maintenance	1.16	2.00	2.29	2.80	5.16	6.20	0.08[5]	0.18[32]	0.85	1.64	1.98	1.483	7.695	1.07	4.96	1.46	B	0.17	0.7604	0.7090	1.29	...	...	...	0.492	0.726	1.948
Train staff (guard, conductor)	0.80	0.80	0.45	0.45	0.45	0.60	0.03[75]	0.14	...	...	(in driving)	...	...	0.62	1.56	0.18	...	0.23	...	...	...	...	...	...	0.444	0.663	1.091
Depreciation and renewal	0.81	0.61	1.00	2.20	3.92	5.60	0.07[43]	0.09[62]	0.69	0.38	...	0.380	0.260	7.40	2.06	1.50	3.20	4.00	...	...	...	...	...	...	0.250	...	...
Total	3.96	6.72	5.40	7.65	13.15	18.10	0.32[25]	0.81[30]	2.35	4.92	7.18	2.858	13.415	14.09	15.11	2.70	8.55	13.75	2.0337	2.3330	3.83	4.97 escudos	5.30 escudos	15.9 escudos	2.150	2.840	6.657
Estimated distance covered before scrapping, used for calculating depreciation charges	950 000 km. (1) 2 850 000 km. (2)	...	600 000 km.	800 000 km.	900 000 km. (3)	...	...	...	...	...	...	8 850 000 km.	...	1 000 000 km	...	1 000 000 km.	400 000 km.	...	...	...	...	500 000	800 000	...	1 000 000	...	...
Amortisation period	10 years (1) 30 years (2)	33 1/3 years (1) 40 years (2)	8 years	8 years.	10 years.	30 years	...	...	8 years	30 years	...	13 years	50 years (1) 40 years (2)	15 years	30 years (1) 40 years (2)	12 to 13 years	10 years	25 years.	...	...	...	7 years	10 years	10 to 13 years	10 years	...	...

(1) Self-contained motive power or locomotive.
(2) Coach part of railcar and electric motor coach, or sets of carriages.
(3) For railcar.

(a) Older type with trailer, 34 places, 105-H.P. Panhard engine.
(b) Modern type without trailer, 46 places, 150-H.P. Hispano-Suiza engine.

at a maximum speed of 140 km. (87 miles) an hour; the cost per railcar-km. is 2.67 lire (4.30 lire per railcar-mile) compared with 7.98 lire (12.84 lire per mile) for a 6-coach steam train.

The cost per mile worked by a railcar is 32 % of that of a steam train.

Here again the cost per seat is lower for the train service.

Tunisia.

The cost of a 400-h.p. diesel-mechanical twin-unit railcar for metre-gauge lines, with 78 seats, is 4.49 fr. per km. (7.23 fr. per mile) compared with 12.60 fr. per km. (20.28 fr. per mile) for a 4-coach train with 208 seats.

The ratio is 35 %.

The cost per seat-km. is 5.08 centimes for the railcar in Tunisia compared with 6 centimes for the steam train (8.17 and 9.66 centimes per seat-mile respectively).

In Tunisia therefore the comparison is always in favour of the railcar without exception.

Table H gives in detail the costs for single and twin railcars for high-speed services and for the corresponding trains, as reported by the various Managements.

3. Triplets for high-speed services.

Belgium.

The 730 and 820-h.p. diesel-electric triplets cost a little more per mile than steam trains of the same capacity.

The difference is due to the higher maintenance costs for railcars compared with trains, to the fact that the depreciation charges are spread over 10 years only, and that the purchase price of the triple railcar is much higher than that of a train, unlike in other countries.

France.

The cost per kilometre of the triplet is 17.30 fr. (27.84 fr. per mile) compared with 22.45 fr. per km. (36.13 fr. per mile) for the steam train with twice as many seats.

The ratio between the costs per mile is 78 %.

Here again the cost of maintenance is very high, though less than the corresponding maintenance costs for the train.

It should be noted in this respect that the triple railcars concerned (*Franco-Belge* type) currently run at speeds lying between 130 and 140 km. (81 and 87 miles) an hour, whereas the steam trains concerned do not exceed 120 km. (75 miles) an hour.

The maintenance costs of the triple railcars are greatly increased through this. On the other hand the engines, which come from abroad, are very costly. Finally, these are luxury cars designed to give the comfort of Pullman trains.

Holland.

The cost of the diesel-electric triplets with 160 seats is 0.38 florins per km. (0.61 fl. per mile), compared with 0.81 florin per km. (1.30 fl. per mile) for a steam train consisting of a van and 4 coaches. The ratio is therefore 46 %.

These figures show that in Holland, not only is the cost per kilometre of a triple set less than half that of the corresponding train, but the cost per seat-km., which is 0.0024 florin (0.00386 fl. per seat-mile) is more than 10 % lower than the cost per seat in a train) (0.0027 fl. per km. (0.00435 fl. per mile).

The comparison is therefore altogether in favour of the triple set which gives the cheapest cost per train-mile and can meet peak traffics just as well as a train service at a lower cost per seat available.

Table I gives details about the cost of triple railcars and express trains for the various Railways.

4. Comparisons between the costs per mile for steam and electric trains.

We obtained from different Railways

TABLE H.

Comparative total costs of railcar and trains. — High-speed low-capacity services.

COUNTRIES.	FRANCE (National Railways Co.).		ITALY.		TUNISIA.	
TRAIN COMPOSITION.	500 to 600-H.P. diesel-mechanical twin railcars, with 90 to 110 seats.	Express train consisting of One 4-6-2 locomotive; 4 bogie coaches; 1 van (metal stock); 260 seats together.	250-H.P. FIAT ALn 40 single diesel mechanical railcar; 30 seats.	Steam train consisting of: One Gr. 671 locomotive; 6 carriages, 1 van; 456 seats together.	300 H.P. metre-gauge diesel-mechanical twin railcar; 78 seats.	Steam train, metre-gauge, consisting of: One class 801 locomotive; 4 carriages; 1 dining-car; 1 van; 208 seats together.
	Cost of railcar, in French francs.	Cost of steam train, in French francs.	Cost of railcar, in lire.	Cost of steam train, in lire.	Cost of railcar, in francs.	Cost of steam train, in francs.
Total cost per train-kilometre	11.10	22.45	2.67	7.98	4.49	12.60
Total cost per available seat-kilometre	0.10	0.077	0.067	0.017	0.057	0.06
Purchase price at present value	2 000 000	6 250 000	630 000 lire	1 119 000 lire	1 255 000	2 562 000
Detail of total cost per train-kilometre						
Driving (driver, fireman)	0.90	1.00	0.25	0.54	0.482	1.128
Fuel or electric power	1.98	3.10	0.42	2.33	0.392	2.912
Management and service in depots	(in driving)	0.45	0.14	0.41	0.050	0.110
Lubricants and sundry stores	0.38	0.65	0.05	0.18	0.246	0.507
Maintenance	4.61	9.00	1.00	3.77	2.311	7.677
Train staff (guard, conductor)	0.55	1.00	—	—	—	—
Depreciation and renewal	2.68	7.70	0.81	0.75	1.010	0.270
Total	11.10	22.45	2.67	7.98	4.491	12.604
Estimated distance covered before scrapping, used for calculating depreciation charges	1 200 000 km.	—	—	—	15 750 000 km.	—
Amortisation period	10 years.	30 years.	8 years.	30 years.	15 years.	50 years (1). 40 years (2).

(1) Self-contained engines (diesel or electric), or locomotive.

(2) Coach part of railcars and electric motor coaches, or set of carriages.

comparative costs which are given in Table J, and require the following comments :

In Belgium, an electric train of two motor coaches with two trailers between them, providing 259 seats, costs 6.22 francs per km. (10.00 fr. per mile) compared with 9.38 francs per km. (15.09 fr. per mile) for a steam train of the same capacity; the ratio of the costs is 66 %.

In *France,* for express trains with the same number of seats (290), the ratio of the costs is 77 %; for the stopping trains it is 61 %.

In *Holland,* an electric train made up of a set of 3 motor coaches and one of 2 motor coaches has been compared with a steam train hauled by a locomotive; the number of seats was 310 and 300 respectively. The ratio of the costs per mile is 70 %.

In *Italy,* for two trains of similar capacity — 176 seats — the ratio is 65 %.

In all these cases electric traction has the advantage over steam traction owing to the low cost of electric current and of the maintenance of the machinery while the costs for the hauled stock and the amortisation charges for the whole train are about the same; in *France* the traction costs of a high-speed electric train consisting of 4 coaches is taken to be 2.70 fr. approximately, to which must be added 3.90 fr. for amortisation of the locomotive, i.e. a total of 6.60 fr. per km. (10.62 fr. per mile), whereas the traction costs are taken to be 8.90 fr. to which must be added 3.10 fr. for amortisation of the locomotive and tender, i.e. a total of 12 fr. per train-km. (19.30 fr. per train-mile). The saving made possible by electric traction is therefore 5.40 francs per train-km. (8.69 fr. per train-mile).

(C) Present policy of the various Administrations.

We asked each Management to be good enough to state its future programme for speeding up passenger services and extending the railcar services, both secondary and high-speed.

We received very interesting replies, so that we think it would be best to reproduce the principal textually.

Belgium.

Secondary lines.

— Use of some light steam locomotives of low power for trains normally carrying more than 120 passengers;

— Use of diesel railcars (140 h.p.) of one class only, with 80 and 120 seats for trains carrying less than 120 passengers. These will be worked as « one-man cars ».

Fifty four-wheeled light railcars have just been ordered.

Lines with fast services.

The *Belgian National Rys. Co.* is not considering extending its stock of high-speed locomotives and railcars; the tendency is to electrify the main lines radiating from Brussels. This will lead to a considerable increase in the speed of all the local, semi-express and express services ,and higher train frequency.

To sum up : extensive railcar programme for the secondary lines; electrification of the main lines radiating from Brussels.

France.

The speeding up of the services on all the lines will be obtained by :

1. Increasing the maximum speeds on the open road;

2. Increasing the speed at which such special points as curves, stations, junctions, turnouts, etc., can be run through without having to slow down, and even doing away with all particular speed restrictions;

3. Increasing the useful power of the locomotives;

4. Lightening the construction of the rolling stock used on the express trains;

5. Finally, electrifying lines carrying very heavy traffic.

As regards the part to be played by

TABLE I.

Comparative total costs of railcars and trains. — High-speed high-capacity services.

—	BELGIUM (National Rys. Co.).		FRANCE (National Rys. Co.).		HOLLAND.	
TRAIN COMPOSITION.	730 and 820-H.P. diesel - electric, types 653 and 654, triple railcars, 229 seats together.	Steam train consisting of: 1 type 62 locomotive, 1 coach with luggage compartment, 50 seats; two 3rd-cl. coaches, 112 seats (metal stock), 274 seats together.	800-H.P. diesel-electric triple railcars, 140 seats.	Express train consisting of: One 4-6-2 locomotive; 4 bogie coaches; 1 van (metal coaches), 290 seats together.	Diesel-electric triple railcars, 160 seats together.	Steam train consisting of: 1 locomotive; 1 van, 4 coaches, 300 seats together.
	Cost of railcar, in Belgian francs.	Cost of steam train, in Belgian francs.	Cost of railcar, in French francs.	Cost of steam train, in French francs.	Cost of railcar, in florins.	Cost of steam train, in florins.
Total cost per train-kilometre	9.78	9.38	17.30	22.45	0.38[6]	0.81[30]
Total cost per available seat-kilometre	0.042	0.034	0.125	0.077	0.00[12]	0.00[27]
Purchase price at present value	5 825 000	2 736 000	4 400 000	6 250 000	195 000	238 000
Detail of total cost per train-kilometre						
Driving (driver, fireman)	0.38	1.22	0.90	1.00	0.03	0.14[06]
Fuel or electric power	0.94	2.48	2.35	3.10	0.03[45]	0.14[40]
Management and service in sheds	0.26	0.26	(in driving)	0.45	0.03[57]	0.10[73]
Lubrication and sundry materials	0.25	0.11	0.65	0.65	0.01[95]	0.00[2]
Maintenance	4.59	3.37	7.65	9.00	0.12[5]	0.18[32]
Train staff (guard, conductor)	0.80	0.80	0.55	1.00	0.03[75]	0.14
Depreciation and renewal	2.56	1.14	5.20	7.70	0.09[83]	0.09[52]
Total	9.78	9.38	17.30	22.45	0.38[05]	0.81[30]
Estimated distance covered before scrapping, used for calculating depreciation charges	1 340 000 km. (1) 4 000 000 km. (2)	—	1 400 000 km.	—	—	—
Amortisation period	10 years (1) 30 years (2)	33 1/3 years (1) 40 years (2)	10 years.	30 years.	Diesel engine, 7 years. Electrical equipment, 15 years. Coach part and running gear, 20 years.	25 years (1) 20 years (2)

(1) Self-contained engines (diesel or electric), or locomotive.
(2) Coach part of railcars and electric motor coaches or set of carriages.

TRAIN COMPOSITION.	BELGIUM (National Rys. Co).		FRANCE (National Rys. Co.).				HOLLAND.		ITALY.	
	Steam train consisting of: 1 type 62 locomotive; 1 One 2nd-cl. coach with luggage compartment, 50 seats; two 3rd-class coaches, 112 seats (metal coaches), 274 seats together.	Electric train consisting of: 2 motor coaches with 2 trailers between them. 259 seats together.	Express train consisting of:		Local train consisting of:		Steam train consisting of: 1 locomotive; 1 van; 4 coaches. 300 seats together.	Electric train consisting of: one 3-coach set + one 2-coach set. 312 seats together.	Light accelerated steam train consisting of: one Gr. 640 locomotive; 2 coaches. 176 seats together.	Electric train consisting of: 1 E 626 locomotive; 2 coaches. 176 seats together.
			1 locom. of 4-6-2 type; 4 bogie coaches; 1 van (metal stock). 290 seats together.	1 electric locom. 2D2 type; 4 bogie coaches; 1 van. 290 seats together.	One 4-6-0 locom.; four 4-wheeled coaches; 1 van. 180 seats together.	1 electric locom. E. BB type; four 4-wheeled coaches; 1 van. 180 seats together.				
	Cost of steam train, in Belgian francs.	Cost of electric train, in Belgian francs.	Cost of steam train, in French francs.	Cost of electric train, in French francs.	Cost of steam train, in French francs.	Cost of electric train, in French francs.	Cost of steam train, in florins.	Cost of electric train, in florins.	Cost of steam train, in lire.	Cost of electric train, in lire.
Total cost per train-kilometre	9.38	6.22	22.45	17.05	18.10	11.25	0.81[30]	0.57[90]	4.92	3.20
Total cost per available seat-kilometre	0.034	0.024	0.077	0.059	0.10	0.062	0.00[27]	0.00[19]	0.028	0.018
Purchase price at present value	2 736 000	5 028 617	6 250 000	9 500 000	3 050 000	4 000 000	238 000	345 000	1 609 000	2 404 000
Detail of total cost per train-kilometre										
Driving (driver, fireman)	1.22	0.28	1.00	0.65	1.70	0.95	0.14[06]	0.03[43]	0.79	0.59
Fuel or electric power	2.48	2.16	3.10	0.75	3.20	0.55	0.14[10]	0.14	1.54	0.61
Management and service in sheds	0.26	0.05	0.45	0.20	0.60	0.30	0.00[27]	0.06[13]	0.41	0.13
Lubricants and sundry materials	0.11	0.02	0.65	0.10	0.20	0.05	0.10[73]	0.00[13]	0.16	0.05
Maintenance	3.37	1.71	9.00	5.85	6.20	3.60	0.18[32]	0.12[47]	1.64	1.41
Train staff (guard, conductor)	0.80	0.80	1.00	1.00	0.60	0.60	0.14	0.04[82]	—	—
Depreciation and renewal	1.14	1.20	7.70	8.50	5.60	5.20	0.09[52]	0.16[92]	0.38	0.41
Total	9.38	6.22	22.45	17.05	18.10	11.25	0.81[30]	0.57[90]	4.92	3.20
Estimated distance covered before scrapping, used for calculating depreciation charges	—	—	—	—	—	—	—	—	—	—
Amortisation period	33 1/3 years (1). 40 years (2)	33 1/3 years (1). 40 years (2)	30 years.	—	30 years.	—	—	—	30 years.	30 years.

(1) Self-contained engines (diesel or electric), or locomotive.

(2) Coach part of railcars and electric motor coaches, or set of carriages.

railcars in speeding up the services, the French National Rys. Co., owing to the falling off of the traffic, has had to reduce considerably the number of supplementary services worked by ultra-high-speed railcars on the main lines, which cost a great deal, and to maintain the old steam services providing connections at every junction.

The normal field of action of the railcar lies in the secondary and cross-country lines taken as a whole.

Apart from the great value of an appreciable reduction in the journey time for the local clientele, this being usually of about 30 %, it becomes possible to provide a great many new connections, either with the express trains on adjacent lines, or with other local trains on the branch lines.

Thanks to the railcar it is thus possible to introduce easy and rapid services between centres which are not directly linked up by main lines.

To sum up : — Electrification of important main lines, improvement of the steam train services on non-electrified main lines, and development of railcar services on all the secondary and cross-country lines.

Holland.

The programme consists in the construction of 18 diesel-electric quintuple railcars (1 800 H.P.), which have just been ordered. In addition, Holland is considering the electrification of other lines and the construction of light railcars.

To sum up : — Large extension of triple and quintuple railcars, and electrification, with extensive use of electric motor coaches, not of trains. No extension of the steam services.

Italy.

Railcars : — Italy is prepared for even higher speeds than those now practised, i.e. between 130 and 150 km. (81 and 93 miles) an hour, so as to be able to introduce trains running at 100 km. (62 miles) an hour on the secondary lines, and at 120 to 130 km. (75 to 81 miles) an hour on the main lines. Same policy as regards the speed of electric motor coaches.

Steam locomotives : — No important modifications are under consideration; the necessary work will be untertaken for streamlining the modern engines, increasing their power and improving their efficiency.

Electric locomotives : — Their power in particular will be increased, so that they can haul heavier trains at 120 km. (75 miles) an hour on the main lines.

To sum up : — Italy does not intend to increase the stock of steam locomotives, but will greatly increase the number of railcars and « electrotrains », to be run as separate units at speeds of 130 and 150 km. (81 and 93 miles) an hour.

Rumania.

Extension of the railcar services by the introduction of a large stock of bogie railcars.

Jugoslavia.

Development of railcar services to give fast communications between important towns and the capital, and to encourage tourist traffic.

Belgian National Light Rys. Co.

Railcars to take the place of all steam locomotives for passenger services.

Tunisian Rys.

According to the programme adopted, all the passenger services, both on the standard-gauge and metre-gauge lines, will be worked in future by railcars, with the sole exception of the long-distance services and night services (Tunis-Algiers, for example) for which sleeping cars will still be hauled by steam locomotives.

Indo-China and Yunnan Railways.

Increase in the number of railcars with the use of special trailers.

* * *

CHAPTER V.

Summaries.

In this report we have shown how during the last few years the Railways, thanks to technical progress, have been able to improve the passenger services, and so recover some of the traffic lost to road competition.

The technical methods employed have been of three different kinds :

1. Speeding up the steam trains, both on the main lines and secondary lines;

2. Electrification of certain lines, then, thanks to this electrification, rearranging the workings, multiplying the services, speeding up the trains, and using electric motor coaches;

3. Replacing steam trains by railcars, to a varying extent, providing more frequent services, and general speeding up of the timings.

We will deal with each of these three methods in turn.

1. Speeding up the steam trains.

This coincided with the introduction of metal coaches, and it is therefore difficult to say how much of the considerable additional expenditure involved is due to each of these factors.

The speeding up was generally effected by demanding an additional effort from the existing locomotives, and by converting them if need be according to new technical principles.

Except the French National Rys. Co., which built 28 new express locomotives from 1934 to 1938, and the Belgian National Rys. Co., which ordered 35 *Pacific* locomotives during the same period, the Administrations (Holland, Italy and Rumania) did not acquire any new high-speed passenger train locomotives these last five years.

2. Electrification.

During the last few years the different railways have continued to extend their electrification programmes, especially on their main lines; *Belgium,* for example, electrified the Brussels-Antwerp line in 1935; *France* electrified the Paris-Le Mans line, and quite recently the Tours-Bordeaux section (which enables the express electric locomotives to run non-stop from Paris to the Spanish frontier, (820 km. = 510 miles); *Holland* has electrified a whole group of lines (Gouda-Utrecht) which were opened to traffic on the 15th May 1935; *Italy* at the end of 1938 put into service 800 km. (500 miles) of newly electrified lines, Rome-Leghorn, Milan-Bologna, Bologna-Ancona, etc.

The Bologna-Florence-Rome-Naples line had been electrified previously.

The replacement of steam trains by electric trains has made possible considerable operating savings — with trains of equal capacity.

The following table sums up the cost

—	Electric. per km. *(per mile)*	Steam. per km. *(per mile)*	%.
Belgium. — Four-coach train (about 260 seats)	6.22 *(10.01)* Belg. fr.	9.38 *(15.10)* Belg. fr.	66 %
France. — Light 5-coach stopping train (180 seats)	11.25 *(18.10)* French. fr.	18.10 *(29.13)* French. fr.	61 %
Express 4-coach (metal) trains (290 seats).	17.05 *(27.44)* French. fr.	22.45 *(36.13)* French. fr.	77 %
Holland. — A 5-coach train (about 300 seats)	0.579 *(0.932)* florin.	0.813 *(1.31)* florin.	70 %
Italy. — 1 locomotive and 2 coaches (176 seats)	3.20 *(5.15)* lire.	4.92 *(7.92)* lire.	65 %

per km. *(per mile)* of electric and steam trains of the same capacity, as given in detail in Chapter IV.

This table shows that once the capital expenditure has been incurred a saving of some 30 to 35 % on the passenger train-mile can be obtained; in addition electric motor coach trains made up of 1, 2 or 3 vehicles can be run, the total cost of which is lower than that of railcars and which often have higher acceleration powers; the cost for the subsequent miles is very little. Finally high maximum speeds are possible.

From the point of view of speed, the remarkable performance of the *Italian* « Electrotrain » may be recalled, and in the matter of acceleration, the motor coach for pick-up services worked on the Paris-Le Mans line. It should also be remembered that thanks to the persistent efforts of Messrs. *Michelin*, the problem of electric traction on pneumatic tyres has now been solved, and passengers can enjoy the much greater comfort derived from the use of such tyres.

Electrification is therefore the ideal solution as it makes it possible to speed up the services considerably, and at the same time reduce the expenditure. It has, however, the drawback of being hardly suitable for lines carrying average or light traffic, whereon the initial capital expenditure seems prohibitive.

3. Operating by means of railcars.

It is generally agreed that the railcar provides the modern solution for lines of average or small importance for which electrification is ruled out.

The total cost per mile of the railcars is, to a varying extent, inferior to that of the corresponding train. As 60 to 70 % of this cost represents maintenance expenses and depreciation charges, there is every likelihood that further technical progress and increased daily mileage will make it possible to still appreciably lower in the near future the total cost per mile of the railcar.

We have devoted a special chapter to peak traffics in this report, and we have noted the difficulties that arise with single railcars as regards capacity, even when they can be coupled together or can haul trailers; we also pointed out that such difficulties do not exist in the case of triple or quadruple railcars which can be coupled together.

The table hereafter based on the information received from 4 different Railways, shows that in certain cases the cost *per seat available* for a railcar *is lower* than for a train.

COST PER SEAT AVAILABLE AND PER KM. (PER MILE).

Country.	Railcar.	Steam train.	%
Belgium . . .	175-H.P. single diesel-mechanical bogie railcar type 601; 104 seats.	Train made up of a locomotive, one 46-seater 1st and 2nd class coach, two 50-seater 3rd-class coaches with wooden bodies and outside plate sheating. Together : 146 seats.	
	0.038 *(0.61)* Belgian franc.	0.046 *(0.74)* Belgian franc.	82
France . . .	500-600-H.P. single diesel-mechanical bogie railcar, Classs C, with special trailer, total capacity : 150 seats.	Train consisting of : a 4-6-0 locomotive, 4 four-wheeled coaches, 1 van. Together : 180 seats.	

COST PER SEAT AVAILABLE AND PER KM. (PER MILE) *(Contd.)*.

Country.	Railcar.	Steam train.	%
France (contd.)	0.09 *(0.145)* French franc.	0.10 *(0.16)* French franc.	90
Holland . . .	Triple railcar, 160 seats.	Steam train consisting of a locomotive + 1 luggage van + 4 coaches : 300 seats.	
	0.024 *(0.0386)* florin.	0.027 *(0.0435)* florin.	89
Tunisia . . .	265-H.P. single diesel-mechanical Renault A.B.J. bogie railcar, 70 seats (140 and 220 if coupled up to one or two cars).	Steam train consisting of : 1 class 181 locomotives, 3 coaches, 1 van. Total : 222 seats.	
	0.04 *(0.064)* French franc.	0.06 *(0.096)* French franc.	66

In Chapter IV, Par. C., we gave the actual opinions of the different Managements about the future of the different methods of traction in view of the general desire to improve the passenger services, in particular by speeding them up.

Our final summaries are as follow :

1. Electrification is the ideal solution for a certain number of privileged lines carrying very heavy traffic, and for suburban lines, especially when current is cheap. The balance sheet is to be prepared once for all, taking the interest on capital into account. Electrification is a safe investment for the railway, especially when hydro-electric power is available. Once the line has been electrified, every improvement as regards speed and comfort that the most exacting passenger could demand can be introduced.

By using special electric motor coach sets that can be coupled together — now an established practice — the services on electrified lines ought to be superior, as regards quality, to the best train or railcar services.

2. Locomotive traction (steam, electric, or diesel-electric) gives the railway the maximum of operating facilities for meeting all service requirements : hauling all sorts of vehicles, sleeping-cars, restaurant-cars, mail-vans, through coaches, international coaches, convertible day-and-night coaches, etc. which will be more and more widely used for long-distance night services.

Traction by powerful steam or diesel locomotives is consequently the best method for non-electrified main lines, in particular for peak traffic services on such lines.

3. We believe that we have made it clear in this report that the triple or quadruple 2nd and 3rd-class railcar, by avoiding the capital expenditure involved in electrifying lines, which is prohibitive on secondary lines, makes it possible to alter the operating methods of a railway system, meeting all peak traffics without difficulty, and, as experience in *Holland* has proved, at a lower cost per seat available than with steam traction.

Under these conditions, the future appears to lie with triple or quadruple railcars in the case of all lines other than the important main lines and electrified lines, it being understood that steam traction will be retained to haul

trains with through coaches, international coaches, sleeping-cars, etc. as listed under (2).

4. If the use of railcars, especially 2nd- and 3rd-class multiple units, has not made greater progress during the last few years on certain railways, this is doubtless because the value of standardisation has not been recognized early enough. With dissimular stock, 30 to 40 % of it must be kept in reserve and traffic peaks are hard to meet, the mileage per vehicle of the stock as a whole is lower than it should be, finally resulting in an adverse balance sheet.

If standard triple or quadruple railcars are to be built, sufficiently powerful diesels must be available, about 600 to 800 H.P., two such engines being required for each set. In addition the weight of such engines must be reasonable, and their maintenance costs very low. As far as we know, the railways have never asked builders to tackle the problem of the 600 to 800-H.P. diesel — which would cost very little to maintain and be perfectly suitable for rail requirements. A few builders have tried to solve the problem themselves at their own expense and risks; some of them designed the engine a little too light, and therefore costly as regards its maintenance, whilst others made theirs somewhat too heavy, though acceptable in the matter of maintenance costs.

A railway type of 600 to 800-H.P. engine for multiple-unit railcars is the fundamental problem still to be solved, though the present designs can be adopted for the first cars, it being understood that after some 500 000 to 1 000 000 km. (310 000 to 620 000 miles) have been covered the engine will be replaced by a proper railway type of engine.

6. Side by side with the quadruple 2nd- and 3rd-class railcar, which in our opinion solves most of the operating difficulties, there is still room, we believe, according to the requirements of individual railways, for 3 other types of railcars, which also should be carefully standardised :

(a) A 600-H.P. single class bogie railcar, able to haul some 50 tons, i.e. 1 or 2 goods wagons, 1 or 2 passenger coaches (if need be a through metal coach). Maximum speed 120 km. (75 miles) an hour.

From the constructional point of view, this railcar might consist of one only of the two power units making up the quadruple railcar, so that the maintenance costs would be reduced to a minimum, as well as the cost of training the staff;

(b) Single 300-H.P. railcar — single class — with mechanical drive — 2, 3 or 4 of which can be coupled together, running at a maximum speed of 120 km. (75 miles) an hour — 1 motor bogie and 1 carrying bogie. This railcar should, if possible, be made wholly of the « observation » type (uninterrupted view for the passengers), and have a horizontal engine fitted under the body;

(c) Small four-wheeled railcar of extremely low cost, which can be used for all the shuttle services to be run at a maximum speed of 60 to 80 km. (37 to 50 miles) an hour on secondary lines on which passenger traffic continues to be worked.

7. With the stock of vehicles described above, the services would be worked as follows :

Passenger trains hauled by locomotives would only be run on the very important main lines, and even on such lines, except during periods of peak traffic, the services would be worked by multiple-unit railcars as far as possible.

On the other lines, all the services would be covered by single or multiple-unit railcars, it being understood that steam traction would be retained in the case of certain night trains with sleeping-cars, international coaches or several through coaches.

On peak traffic days, all the railcars

would be concentrated on other than the main lines, the 300-h.p. cars being coupled up or run as twins, the 600-h.p. cars hauling metal or other coaches, and the quadruple railcars, — if need be several of them coupled up — would be used for services on the lines acting as feeders to the main lines. The services on the latter would be worked entirely by trains hauled by locomotives : the additional steam locomotives needed on peak days should be locomotives suitable for mixed traffic (passenger and goods), and outside traffic peaks would be used exclusively for the goods services.

The suburban services on non-electrified lines would be covered advantageously by the same quadruple railcars.

8. To sum up, electrification of the important main lines with extensive use of electric motor coaches. Creation of a strictly standard stock of quadruple railcars which can be coupled together, such railcars having two 600-800 h.p. engines, and being fitted out for 2nd and 3rd-class day services as well on the electrified main lines as on the secondary and suburban lines. Consequently, no more metal coaches would be built once the stock reached a certain number, and, as regards steam traction, only locomotives capable of hauling heavy goods trains as well as passenger trains on peak days would be adopted exclusively. For the subsidiary services with reduced traffic, single railcars able to haul some 50 tons if necessary; in addition 300-h.p. single « observation » type railcars for the least important services and for tourist traffic.

* * *

The summaries given above are based, for the most part, on the total cost figures received from the different Managements for their various train-miles.

These costs correspond to the actual expenditure on the train and essentially include the expenditure on motive power and rolling stock (depreciation charges, maintenance, fuel, etc., engine and train crews) but do not include the station or permanent way costs.

These summaries are therefore valid only insofar as the station and permanent way costs remain the same; now, such expenses represent about 40 % of the total passenger service costs (15 % for the stations and 25 % for the permanent way), whilst the train costs amount to 55 to 60 % of the same total expenditure.

The report should therefore be completed by a thorough investigation into the savings made possible by the various methods of traction as regards the operating and the permanent way.

If the savings on the stations and permanent way were proportional to the savings on traction, the financial results of the new methods would have to be increased by about 66 %; inversely an additional expenditure on operating and the permanent way would easily counterbalance the savings made on traction.

In view of the great interest of the question for the future of the railway, we are of the opinion that the improvements and savings in the operating and permanent way maintenance made possible by the use of the different methods of traction, in particular railcars and electric motor coaches, should be investigated.

NEW BOOKS AND PUBLICATIONS.

[621. 153. 3]

Handbuch für Kesselprüfer, Bearbeitet von Fachleuten der Deutschen Reichsbahn (*Handbook for the inspection of boilers*, edited by specialists of the German State Railways). One volume, (6 1/4 × 4 3/8 inches), 400 pages and 294 figures. — 1939, Otto Elsner, Verlagsgesellschaft, Oranienstrasse, 142, Berlin, S.W. 68. (Price : 4.50 Rm.).

In this new handbook, published by Messrs Elsner, the authors have endeavoured to bring together all the regulations, specifications and instructions of the German State Railways concerning the inspection, maintenance, repair and testing of steam equipment in general and locomotive boilers in particular in a very concise way; the work will therefore be of interest to all the technical staff concerned with steam locomotive operating.

The first chapter is devoted to the general regulations on the use and inspection of boilers, and especially steam locomotive and railcar boilers : such as permits to put them into use, safety devices specified, periodical inspection and tests, repair periods, etc. The other sections of this chapter deal with stationary boilers, marine boilers, steam vessels, and low pressure steam equipment.

The book then gives the regulations on the use of compressed air or gas cylinders, cranes, lifts and hoists, weighing devices and weights, all of which are generally inspected by the same staff as that responsible for the supervision of steam plant.

The most important part of the book is devoted to the locomotive boiler, its inspection, repair, and testing; it includes amongst others the instructions relative to the method of repairing all parts of the boiler and its fittings, a description of the plant and tools used in the boiler shops, a report on the use of flame and electric welding for boiler repairs, etc.

The book ends with the regulations about the construction, maintenance and inspection of acetylene gas generators, as well as the periodical inspection of the various equipment used in oxyacetylene welding.

The book is designed on the same lines as *Elsner's Handbooks for the locomotive and rolling stock department and repair shops of the German State Railways*, which we reviewed in the June, 1938, issue of the *Bulletin*. Like these other handbooks, it has been edited with the greatest care and is copiously illustrated. It is a first class collection of information on the subject in question.

A. C.

[621. 431. 72]

BRIAN REED. — **Diesel locomotives and railcars** (2nd Edition). — One volume (8 3/4 × 5 1/2 inches), 210 pages, 143 figures. — 1939. The Locomotive Publishing Co. Ltd., 3, Amen Corner, London E. C. 4. (Price : 6 shillings nett.)

The first edition of Mr. Brian Reed's book was published in 1935. Since then the rapid evolution of the diesel engine in connection with railway traction has continued, and the book has been completed and brought up to date in order to take into account recent improvements and the new applications made in the numerous countries where this method of traction has been adopted.

The principal subjects dealt with in this book are as follows : — First of all the very fully documented discussion on the comparative advantages of diesel and steam traction, based on the statistics of the operating costs supplied by the railways, has a very special interest; main line diesel locomotives as well as shunting engines and railcars are dealt with. A descriptive chapter then gives the principal characteristics of the stock in service in the chief countries of Europe, Asia and America.

The special features of diesel rail traction are dealt with in a separate chapter. The question of the high speeds made possible by the diesel engine, in particular, is examined, and the special braking arrangements necessitated. Particulars relating to the construction of the bodies and bogies are also given.

The book then studies the diesel engine itself : weight, size, method of mounting on the vehicle, fuel injection and consumption, supercharging, etc.; Maybach, Leyland, Busch-Sulzer, Ganz, Frichs, Gardner, Sulzer, Saurer, Renault, M.A.N., horizontal D.W.K. and Winton engines are dealt with more particularly; the leading characteristics of these types are summed up in a general table.

After some information about engine auxiliaries : cooling, lubricating, starting, and exhaust arrangements, the book then gives a comparative study of the chief transmission systems; the efficiency curves are analysed, and the tractive effort in terms of the speed in the case of direct drive, mechanical, electrical or hydraulic transmission. Each of the three principal types of drive is dealt with in a special chapter; in the case of mechanical transmission, the author particularly dwells on the Maybach and Winterthur systems; on the Ganz, Mylius, Cotal and Wilson gear boxes; amongst the hydraulic transmissions examined, we may mention the Voith-Sinclair, and Lysholm-Smith, and amongst the electric transmissions, the LEMP, R.Z.M., Brown-Boveri, Gebus, Örlikon, etc.

This new, well up-to-date edition of a very practical and fully documented book will certainly be very well received by those concerned with diesel traction.

A. C.

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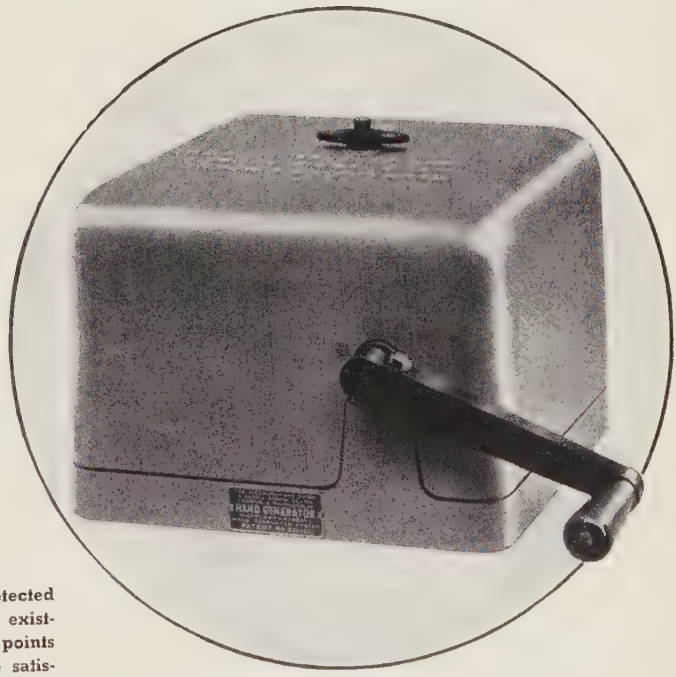

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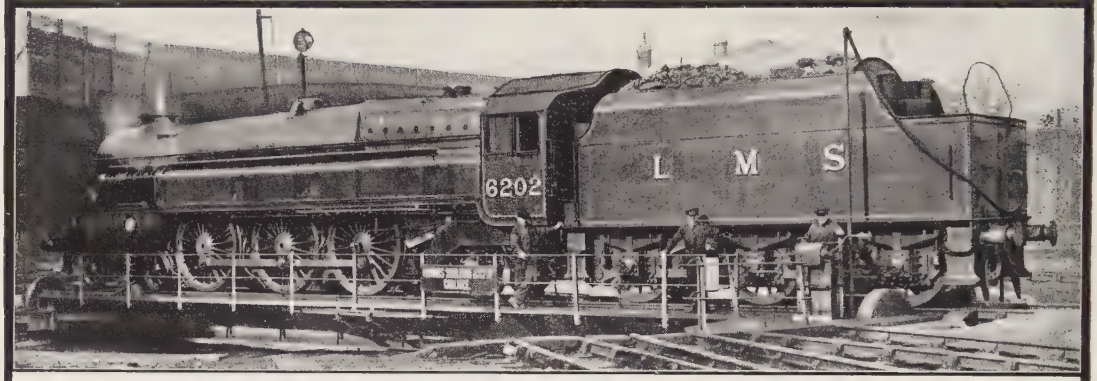

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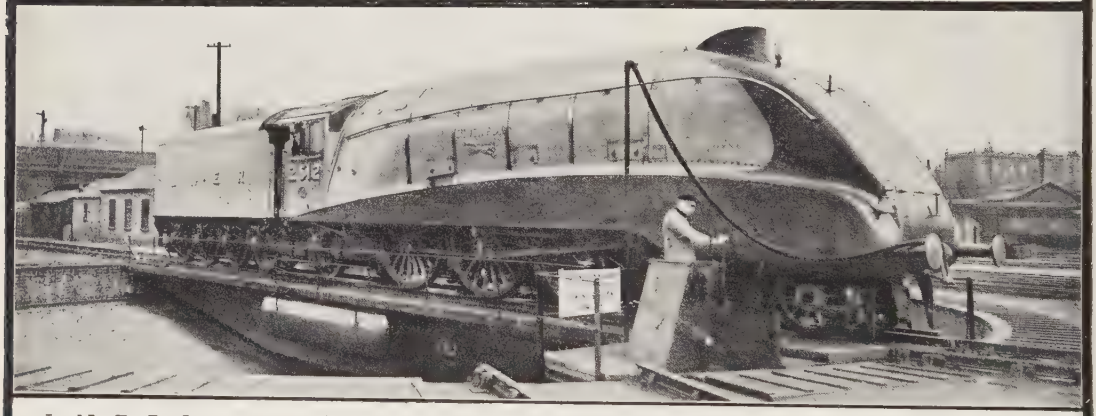

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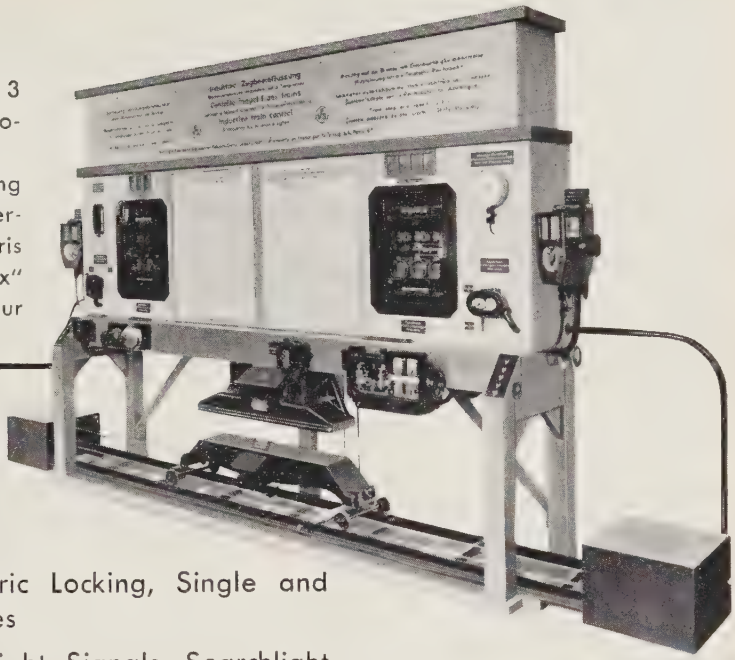

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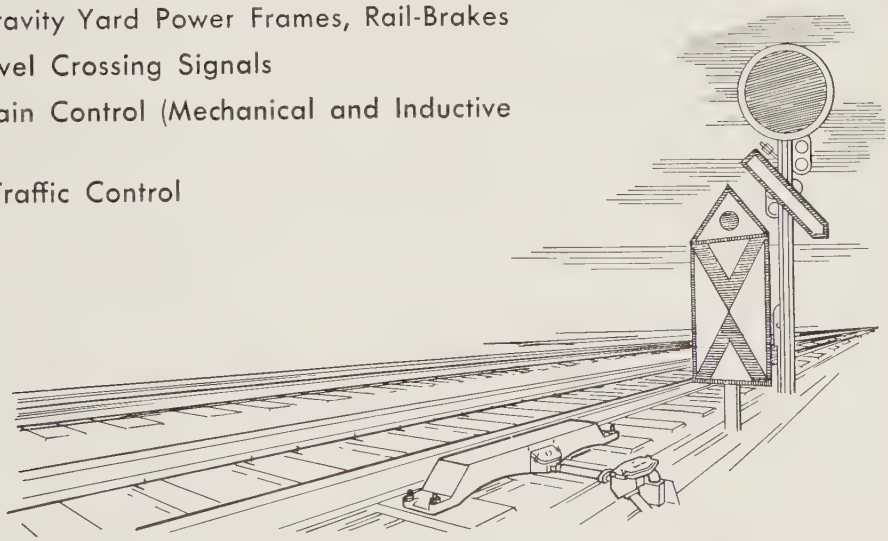

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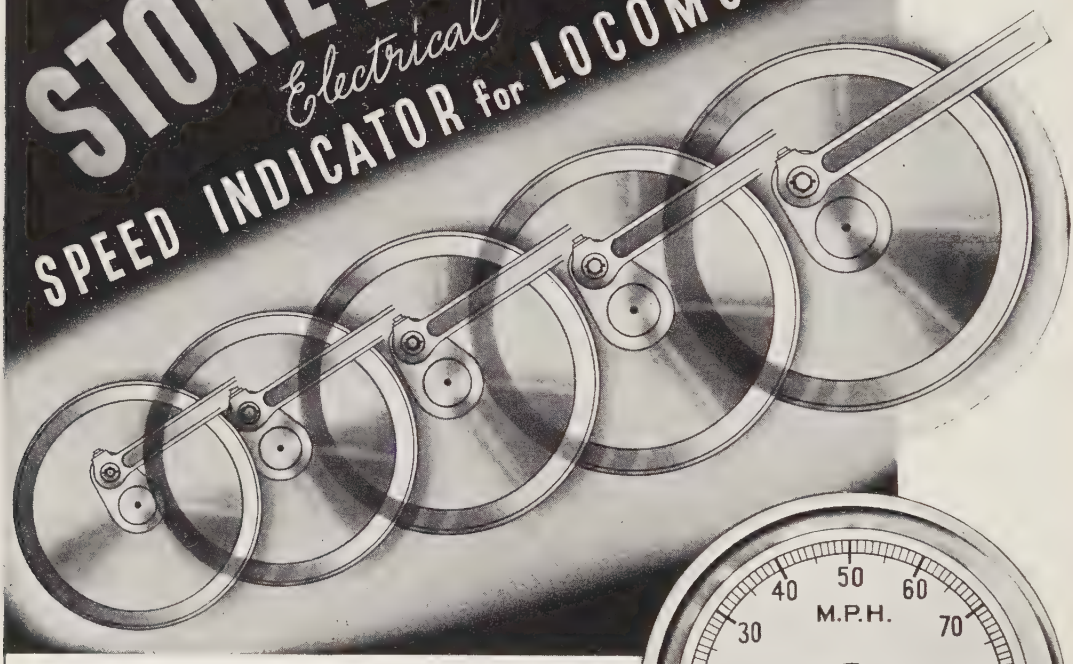

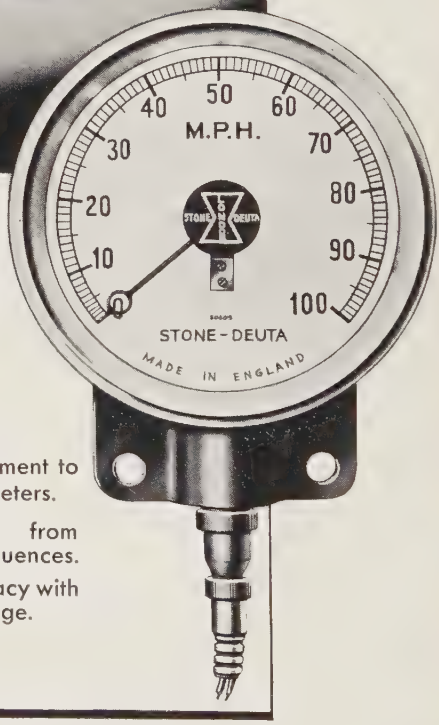

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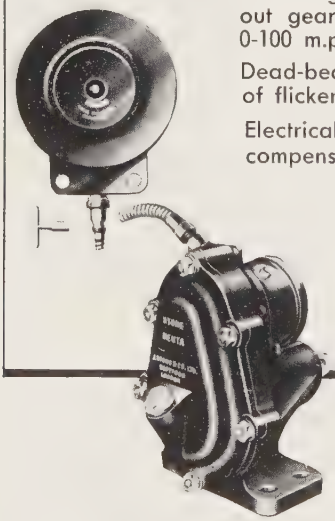

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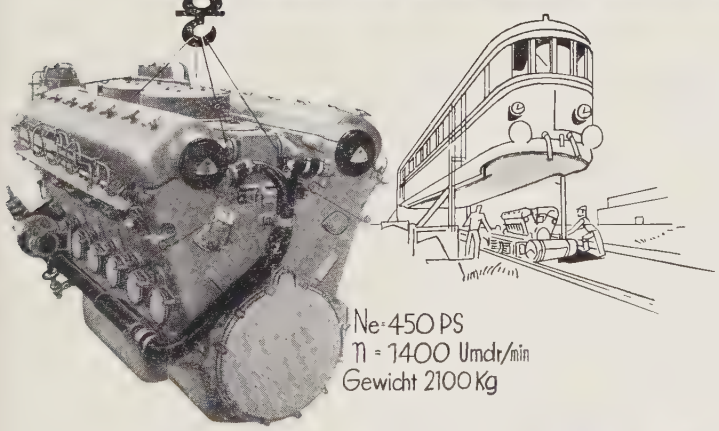

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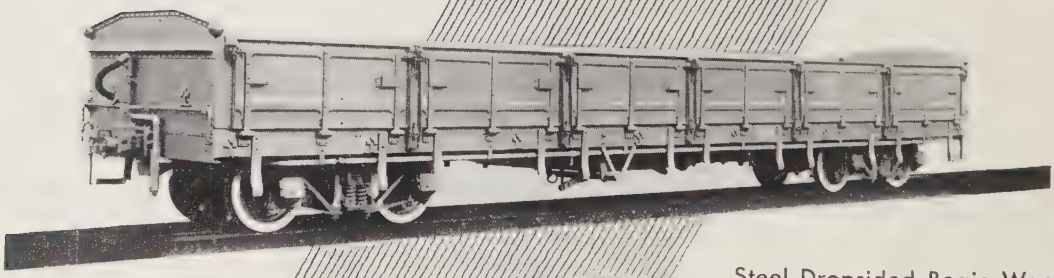

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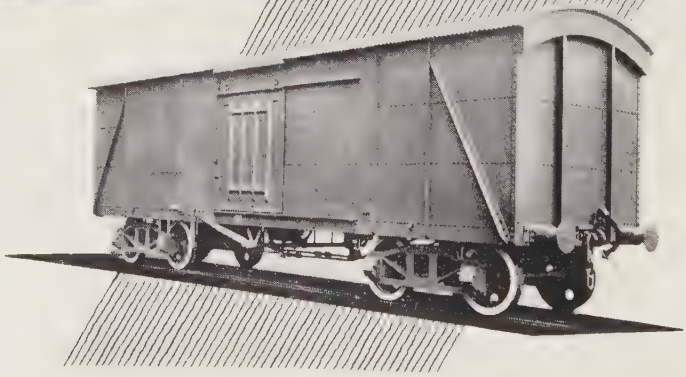

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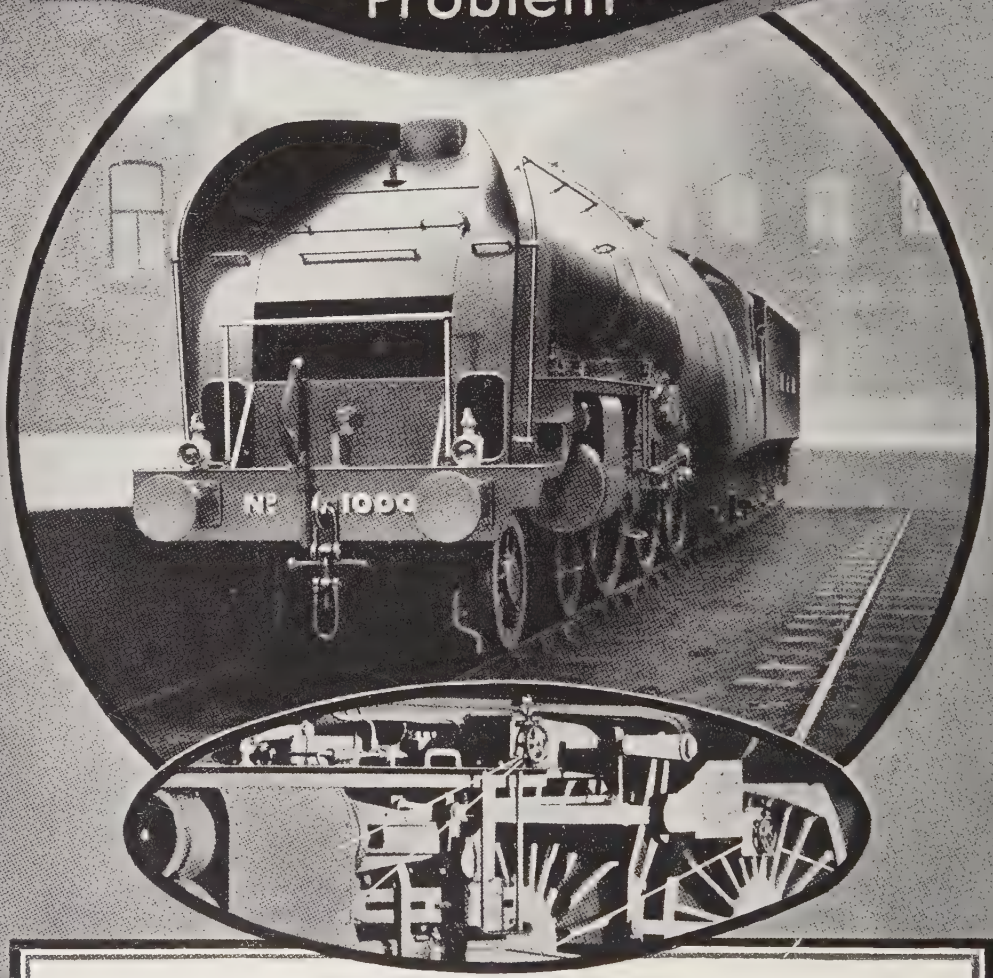

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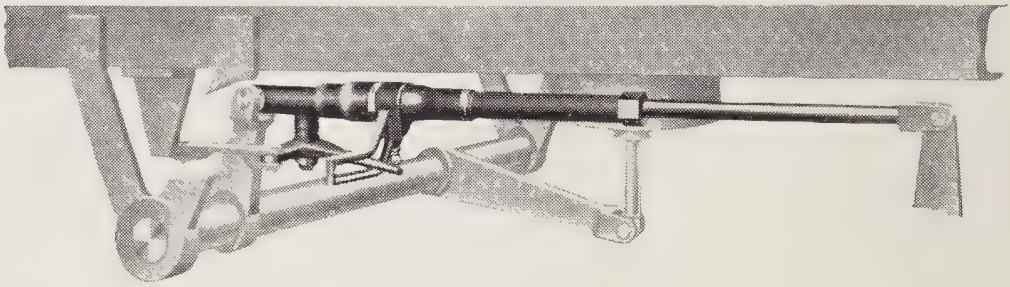

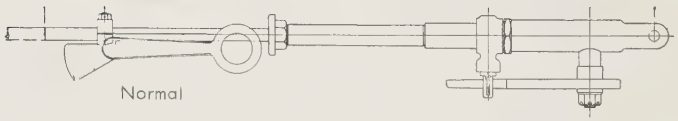

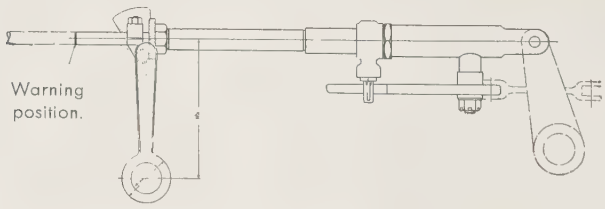

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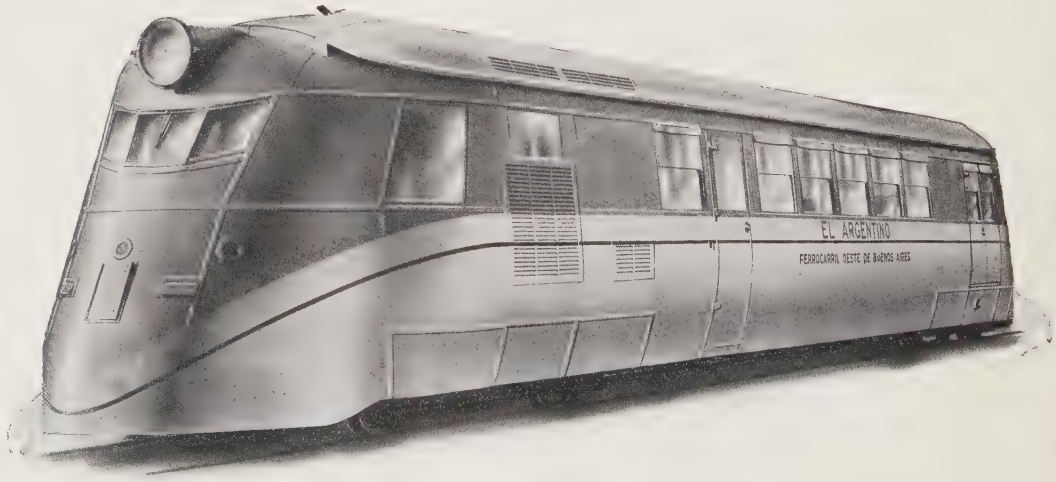

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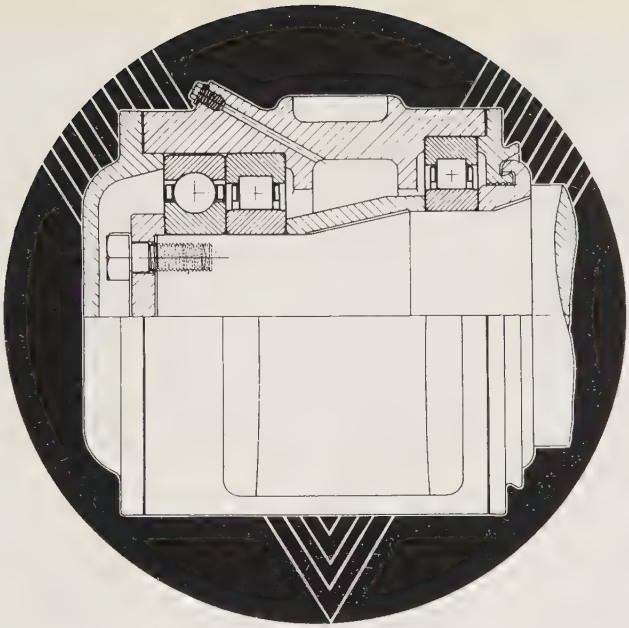

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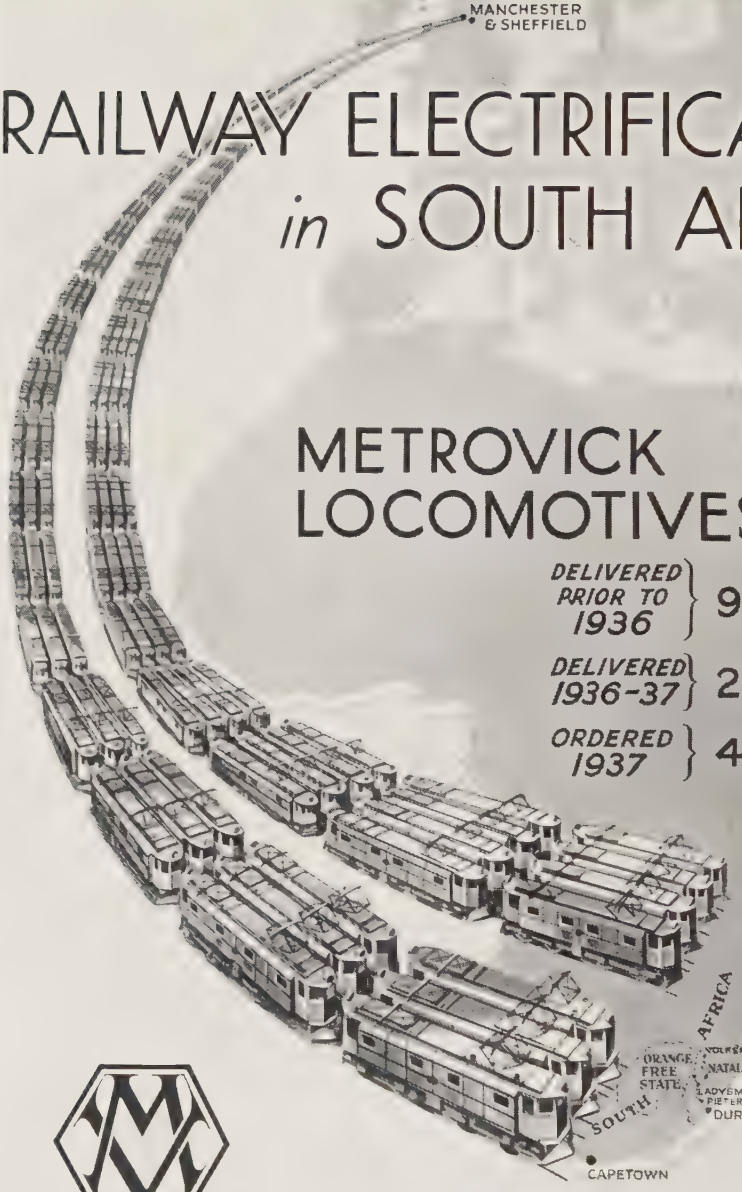

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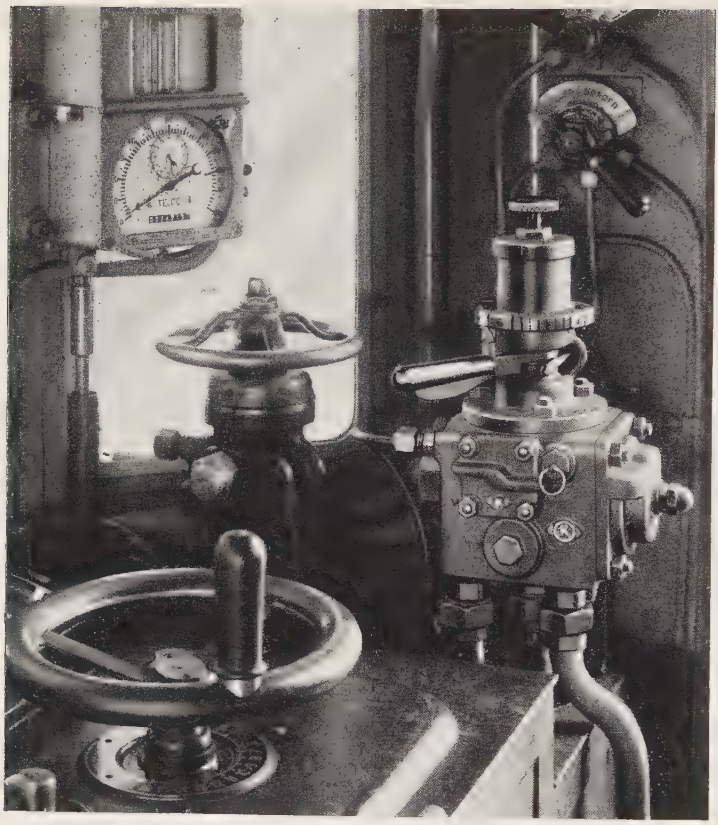

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CONTENTS OF THE NUMBER FOR JUNE 1939.

1939 **385 .114 & 656 .22**

Bull. of the Int. Ry. Congress Ass^{on}, No. 6, June, p. 515.

ROHDE, STROEBE, and FESSER. — **Methods used to speed up passenger trains** and the resulting expenditure. In particular, **operating by means of railcars** and the financial results obtained by this method (Question I, Enlarged Meeting of the Permanent Commission, July 1939). — Report (*Germany, Bulgaria, Denmark, Hungary, Norway, Sweden and Switzerland*). (13 500 words, tables & figs.)

1939 **656 .2**

Bull. of the Int. Ry. Congress Ass^{on}, No. 6, June, p. 559.

GOURSAT. — How should the problems of **simplifying the working** be considered in the future in the interest both of the public and of the railways? (Question II, Enlarged Meeting of the Permanent Commission, July 1939). — Report (*Continental Main-Line Railways, except Belgium*). (5 500 words.)

1939 **385 .114 & 656 .22**

Bull. of the Int. Ry. Congress Ass^{on}, No. 6, June, p. 569.

DUMAS (L.). — **Methods used to speed up passenger trains** and the resulting expenditure. In particular, **operating by means of railcars** and the financial results obtained by this method (Question I, Enlarged Meeting of the Permanent Commission, July 1939). — Report (*Belgium and Colony, France and Colonies, Greece, Italy, Luxemburg, Netherlands and Colonies, Portugal and Colonies, Rumania, Jugoslavia*). (24 000 words, tables & figs.)

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Bull. of the Int. Ry. Congress Ass^{on}, No. 6, June, p. 657.

NEW BOOKS AND PUBLICATIONS. — **Handbuch für Kesselprüfer** (*Handbook for the inspection of boilers*), by specialists of the German State Railways. (350 words.)

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OF THE

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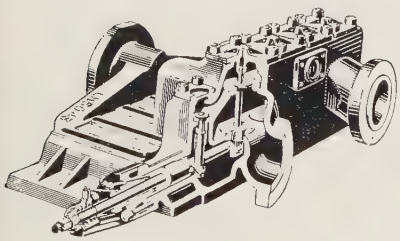

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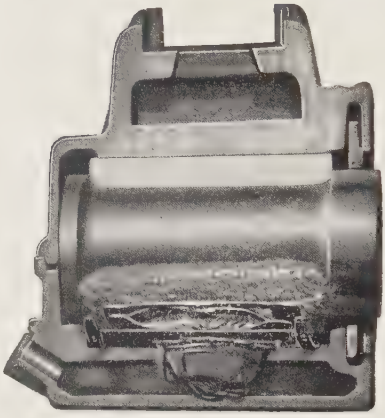

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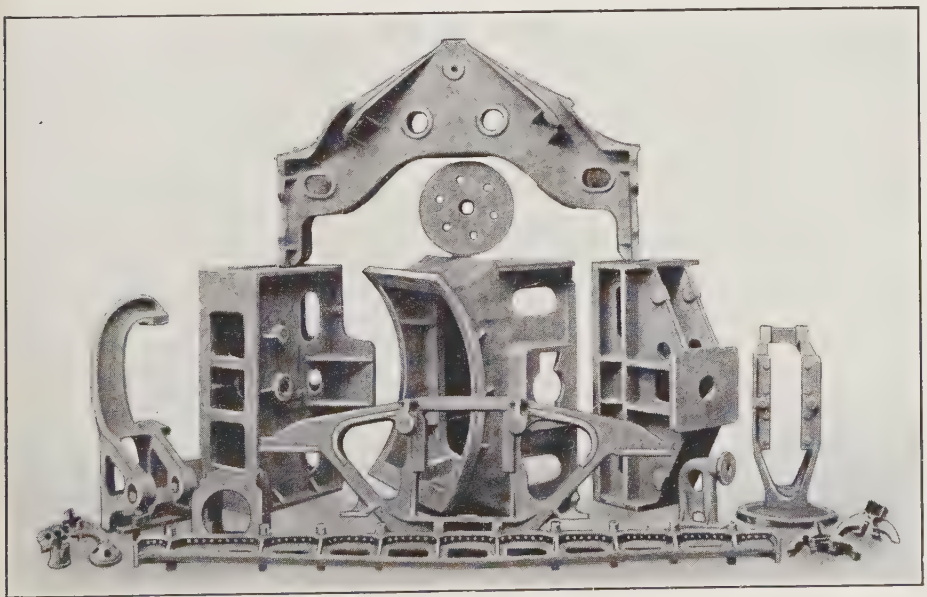

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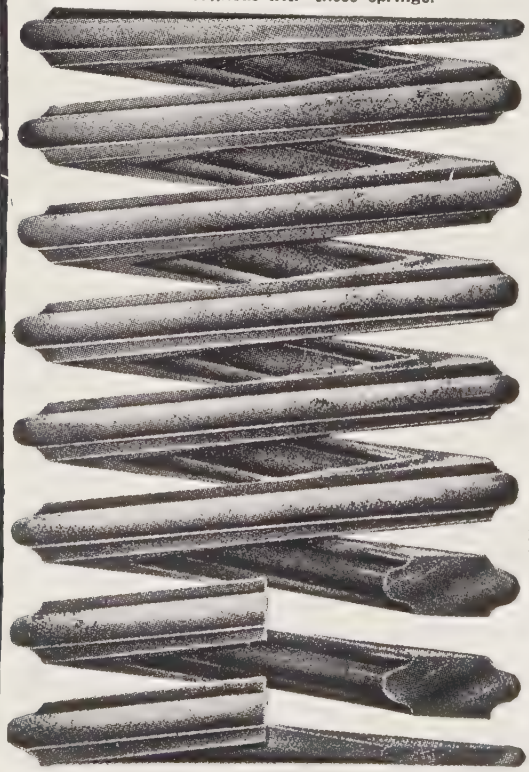

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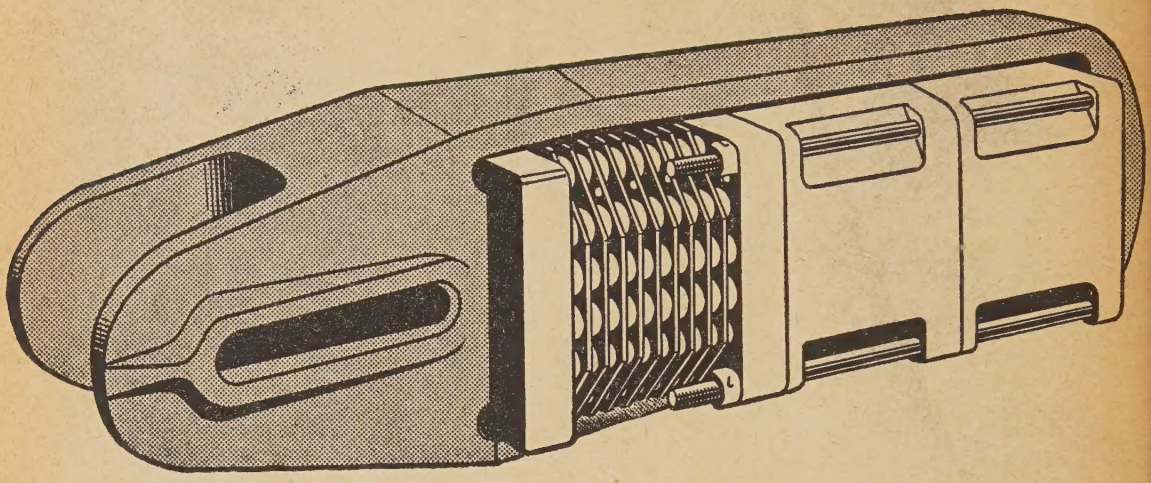

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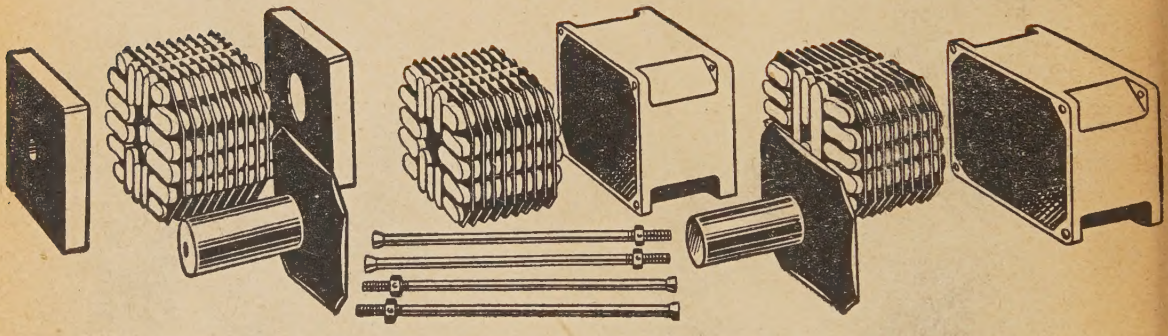

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